TECHNICAL MEMORANDUM

1986 ANNUAL REPORT
RURAL CLEAN WATERS PROGRAM

by

Gary J. Ritter
and
Eric G. Flaig

January 1988

Water Quality Division
Resource Planning Department
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EXECUTIVE SUMMARY

The objective of the Florida Rural Clean Water Program (RCWP) is to identify the effectiveness of BMPs based on observed changes in water quality. Because a water quality monitoring network existed prior to the inception of the RCWP project, four years of baseline data were available before BMP implementation. The availability of this data base enabled researchers to divide the program into three phases to better evaluate water quality concurrently with the scheduled implementation of BMPs. These phases are identified as the pre-BMP, transition, and post-BMP periods. From a basin-wide perspective the program is moving out of the transition period into the post-BMP period. Approximately 78 percent of the 63,109 critical acres in the Taylor Creek/ Nubbin Slough basin are covered by BMPs, and all but two landowners with holdings representing seven percent of the projects critical acres, are under contract to implement BMPs. The majority (greater than 40 percent) of BMP implementation has occurred during 1986, therefore, the impact on water quality to date may be minimal. The primary objective of this report is to provide a preliminary data evaluation of total phosphorus concentration data using seasonal Kendall Tau non-parametric trend analysis and relating these trends to the observed changes in land use practices on a sub-watershed and basin level.

MAJOR FINDINGS

A preliminary analysis using a non-parametric Seasonal Kendall Tau trend test was performed on total phosphorus concentrations to determine if there has a significant change during the period of BMP implementation. A non-parametric method was selected due to the abnormal characteristic of the total phosphorus concentration data. Typical frequency distributions are positively skewed with high peakedness and seem to occur at stations that do not have continuous flow. This situation exists in the small tributaries. However, more normal distributions exist

in the larger branch of Taylor Creek and in the L-63N interceptor canal, because a greater amount of mixing occurs in these areas.

The trend test was conducted on data from 14 stations for a period of record from 1978 to October 1986. Significant trends in water quality at the 5 percent level were detected at nine of the fourteen stations. These stations were located in the following subwatersheds: N.W. Taylor Creek, Otter Creek, Williamson East Lateral, Taylor Creek Main Branch, Mosquito Creek upstream, Mosquito Creek downstream, Taylor Creek Headwaters Confluence, Henry Creek, and S-191. At seven of these nine stations: Otter Creek, Williamson East Lateral, Taylor Creek Main Branch, Taylor Creek Headwaters Confluence, Mosquito Creek upstream, Mosquito Creek downstream, and S-191, the long term total phosphorus concentrations exhibited a decreasing trend.

Where corrected for covariance, only data at three stations (Otter Creek, Mosquito Creek upstream and downstream) showed significant trends at the 5 percent level. Only one site, Otter Creek, exhibited a significant trend at the 1 percent level. This was attributed to a dairy barn shutdown in the fall of 1981.

In successive tests at each station, the data were also stratified into 26, 23, 8, 4, and 2 seasons for each year based on either the calendar year or a seasonal year. Lower significance levels resulted where more seasons were considered, and where the seasons were adjusted to coincide with the wet-season dry-season behavior. The estimated values for trend slope varied arbitrarily with the number of seasons. The probability levels were higher for all calculations when serial dependence was considered.

Emphasis on efficient waste water utilization, diversion of direct runoff from high intensity pastures, timing of pasture fertilization, and fencing cows out of the major water courses throughout the basin can be attributed to observed improvements in water quality at six of the seven stations that exhibited a significant downward trend through the period of record. Decreasing trends in total phosphorus concentrations at the seventh station, S-191, is probably reflecting a cumulative effect of the land use and land management changes that have occurred at the upstream stations. However, it should be noted that this analysis is preliminary and that the concentration data have not been corrected for variation in flow. Because flow is a function of the antecedent rainfall and ground water conditions, the variability of these parameters from year to year could also affect the long term water quality trends.

CONCLUSIONS

Based on the results of the Seasonal Kendall Tau trend analysis, the following points can provide further insight into the cause and effect of the long term water quality trends experienced at nine of the fourteen test stations:

1. Long term variations in rainfall, depth of ground water, and flow can influence changes in water quality and must be considered when evaluating changes in land use and land management practices and their impact on water quality.

2. More efficient use of dairy waste water and effective management of waste storage lagoons will result in improvements in downstream water quality.

3. The shutdown of the dairy operation in Otter Creek is a major factor for the significant downward water quality trend observed in this sub-watershed. However, this situation has also resulted in a masking effect for determining impacts of other BMPs implemented in Otter Creek.

4. Effective timing of fertilizer on beef cattle and dairy operations seems to have a positive impact on water quality.

5. Fencing cows out of the streams is an example of a more passive BMP. External factors, such as increased cow numbers, changes in fertilizer applications, and point sources of runoff from high intensity grazing pastures, seem to mask any short term effects of fencing.

RECOMMENDATIONS

It is apparent that due to the short time period during which the present level of BMP coverage has been in place, preliminary findings, no matter how positive, must be carefully scrutinized. The following recommendations for future evaluation and reporting are:

1. Future water quality analysis should adjust for variations in flow and ground water and also take into account changes in cow numbers during the study period. This will involve developing a simple model to account for these major variables.

2. Loading data should be analyzed on a sub -watershed scale where flow data is available. Using available rainfall data, flow data can be interpolated for sub-watersheds where flow measurements are not available.

3. BMPs that require more active management such as dairy waste water utilization, timing of fertilizer applications on dairy and beef operations, and controlling the release of high intensity area runoff seem to have the greatest impact on water quality. Future recommendations for BMPs should stress these types of activities. Active agricultural land use management and on farm water control hold the key to continued water quality improvements throughout the basin.

4. Farm owners should take a more active role in educating their barn managers on matters concerning maintenance and upkeep of BMPs as well as provide rational for implementing BMPs.

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ACKNOWLEDGEMENTS

This report is the first in a series of reports that will evaluate, both statistically and intuitively the long term impacts of BMPs in terms of reducing the amount of phosphorus entering Lake Okeechobee from the Taylor Creek/ Nubbin Slough basin. The water quality and hydrologic data provided in this report was generated over many years of intensive research by state and federal agencies. Preceding evaluations and research on this continuous data base have provided great insight for the development of agricultural management strategies to control phosphorus runoff on beef and dairy operations throughout the basin.

The authors wish to recognize the efforts of the following agencies for their continued technical and research support in the Taylor Creek/ Nubbin Slough basin: the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, the University of Florida (IFAS), the County Extension Service, and the Agricultural Research Service (USDA). Without this unique blend of local, state, and federal support, and without the unyielding cooperative support of the local landowners this program could not have progressed to the present stage of evaluation.

A special thanks go to all those who provided their careful critique of this manuscript and to the dedicated data collection efforts of field technicians, Boyd Gunsalus, Elaine Rankin, and Steve Magee.

ABSTRACT

As of October 1986, 78 percent of the critical acres in the Taylor Creek/ Nubbin Slough basin were covered by BMPs. Emphasis on efficient waste water utilization, diversion of direct runoff from high intensity pastures, timing of pasture fertilization and fencing throughout the basin has resulted in improved water quality in Mosquito Creek, Otter Creek, and Williamson Ditch. The cumulative effect of these changes in land use practices has resulted in decreasing total phosphorus concentrations at S191. The time series of biweekly total phosphorus concentration data were analyzed for long term trend using the non parametric Seasonal Kendall Tau trend test corrected for serial correlation. The trend test was conducted from 14 stations for a period of record from 1978 to present. Significant trends in total phosphorus at the 5 percent level were detected at nine of the fourteen stations. Long term total phosphorus concentrations were found to have decreased at seven of the nine stations. These trends were significant without considering serial dependence. Only one site, Otter Creek, had a significant trend at the one percent level. This was probably attributable to the shutdown of an upstream dairy barn in the fall of 1981. In computing the test statistic selection of the seasons for stratifying the data, significance levels were lower when the seasons were adjusted to coincide with the wet season - dry season behavior, and the estimated values for trend slope varied arbitrarily with the number of seasons. The probability levels were higher for all calculations when the serial dependence was considered.

Key words: BMPs, non-parametric, Seasonal Kendall Tau, Taylor Creek/ Nubbin Slough, S-191.

INTRODUCTION

Encouraging progress has been made toward completing best management practice (BMP) implementation during 1986. Approximately 78 percent of the project's 63,109 critical acres are covered by BMPs, and all but two landowners with holdings representing 7 percent of the project's critical acres, are under contract to implement BMPs. The objectives of this year's water quality evaluation are:

1. Update annual mean and maximum values during 1985 and 1986 for all water quality stations.
2. Provide a summary of weekly rainfall and ground water stage (from 1978 through 1986) at four stations located in the Upper Taylor Creek watershed.
3. Update wet season time series graphs at the nine major tributaries to include the 1986 wet season data.
4. Provide preliminary data evaluation of total phosphorus concentration data using seasonal Kendall Tau non-parametric trend analysis and comparing these trends on a sub-watershed and basin level.

Products for objectives one and three will be provided in an appendix following the text.

MATERIALS AND METHODS

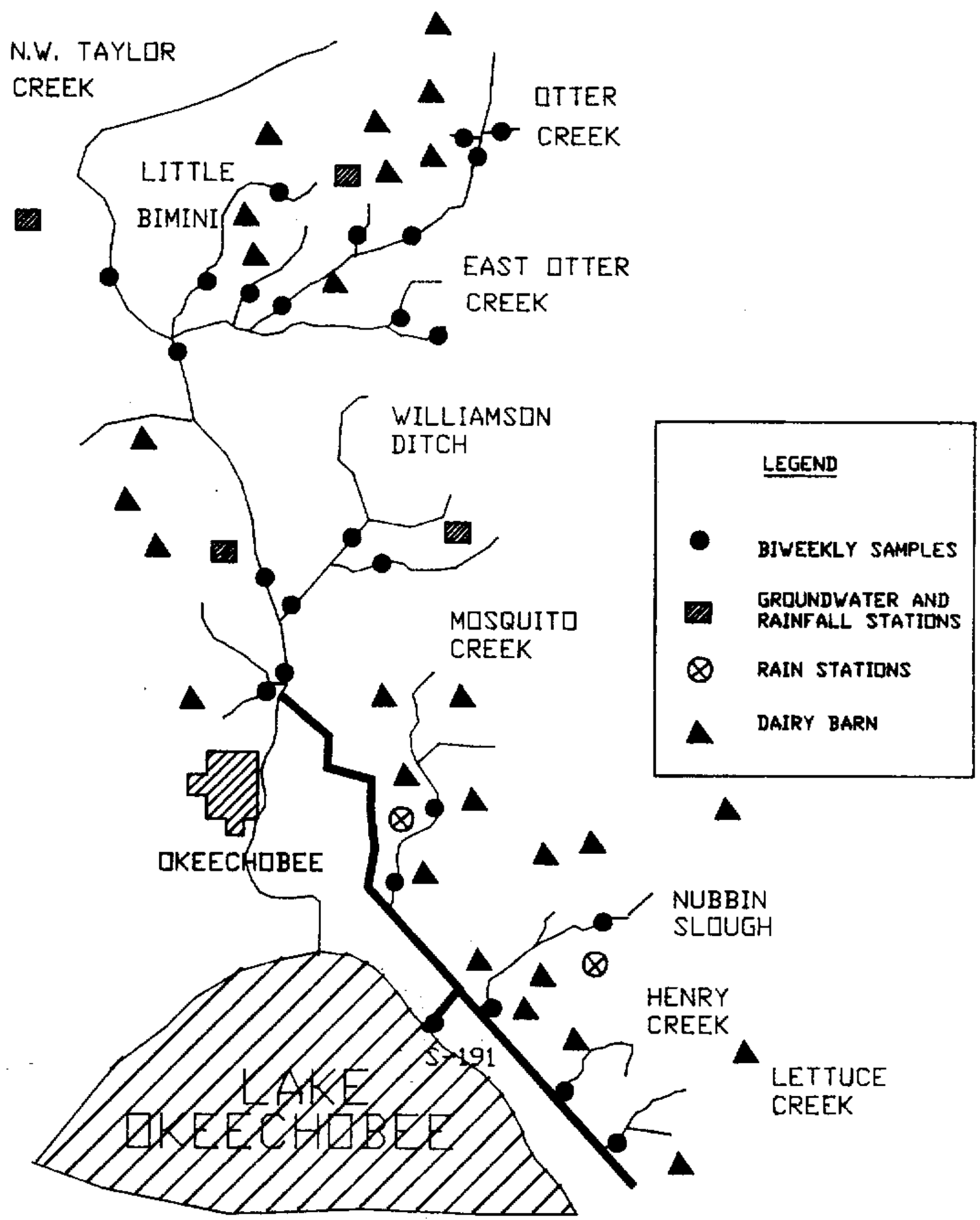
Water quality samples are collected biweekly.throughout the Taylor Creek/ Nubbin Slough watershed. Methodology of sample collection and storage is presented in Ritter and Allen (1982). Water quality samples are analyzed for the following chemical constituents: total-p, ortho-p, nitrate, nitrite, ammonia, and total kjeldahl nitrogen. Samples are also analyzed for pH, specific conductivity, turbidity (NTU), and color. Procedures for sample analysis are presented in Ritter and Allen (1982).

RAINFALL AND GROUNDWATER

Rainfall and groundwater levels are monitored at four stations throughout Upper Taylor Creek. Two rainfall stations are also monitored in Lower Nubbin Slough (Figure 1). Analysis performed by Heatwole (1986), Capece (1984), and Konyha (1982) have indicated that a strong physical relationship exists between water table depth and the volume of rainfall runoff. It is also believed that water quality is strongly related to the volume of rainfall runoff and water table depth in this area. The possible relationships between rainfall volume, water table depth, and water quality needs to be analyzed more closely. This report will summarize the weekly rainfall volumes and water table depths from 1978 through 1986 and interpret the water quality data. This hydrologic data will eventually be incorporated into future trend analysis to explain the variability in the water quality data base, and in turn, interpret changes in water quality due to implementation of BMPs.

Figures 2 through 5 depict weekly rainfall and water table depths at four stations located in the Upper Taylor Creek Basin (Figure 1), and biweekly total phosphorus concentrations at corresponding water quality stations. These figures illustrate the weekly variability in rainfall that existed throughout the study period. Also illustrated are corresponding weekly water table depths. Water table response to rainfall depends on the amount of rainfall, soil moisture conditions, and existing surface water conditions. There may be a direct relationship between surface water and shallow ground water in this area. It appears that during periods where the water table depths are less than two feet below the surface phosphorus concentrations seem to increase, affecting.water quality concentrations, For this reason a closer examination of relationship between water table depth and water quality is needed. While this is beyond the scope of this report, we will later attempt to integrate rainfall and depth of water table and compare them to the present level of trend analysis. No attempt will be made at this time to physically incorporate this data into the trend analysis.

FIGURE 1 TAYLOR CREEK/NUBBIN SLOUGH WATERSHED



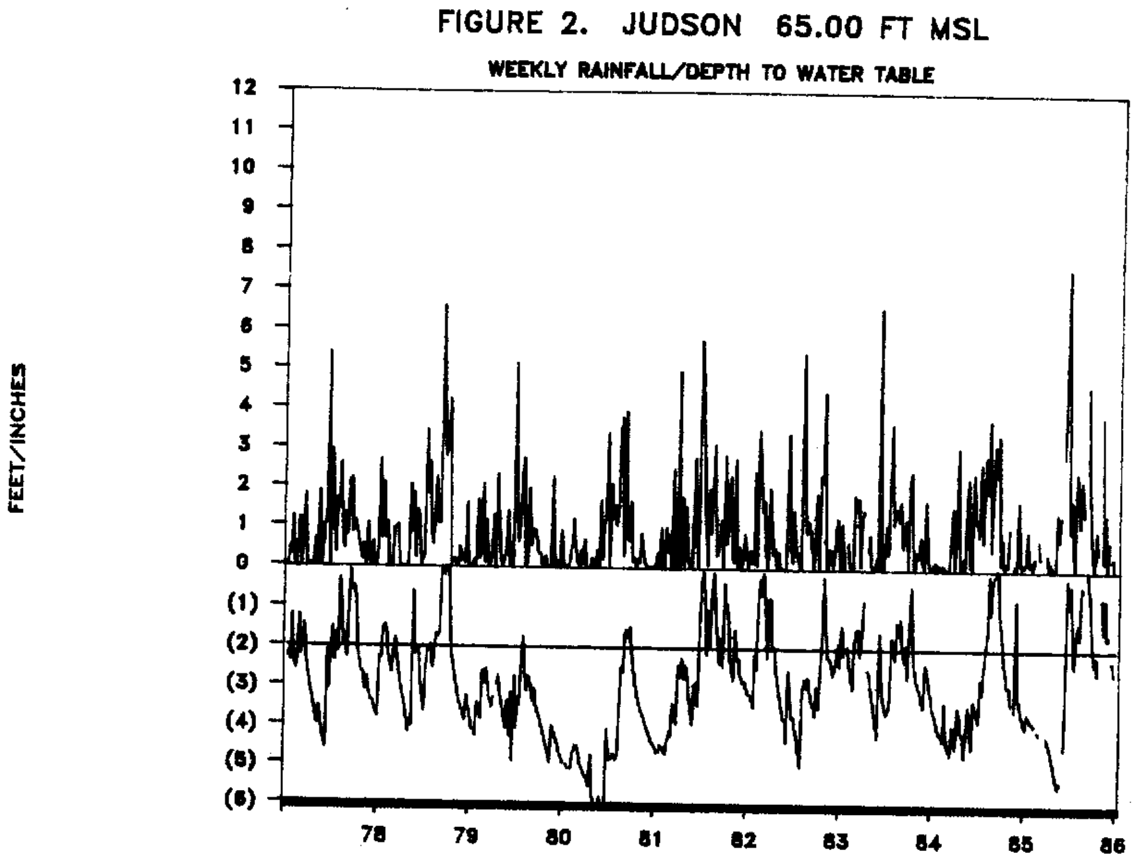


FIGURE 2. JUDSON 65.00 FT MSL
WEEKLY RAINFALL/DEPTH TO WATER TABLE
FEET/INCHES
12
11
10
9
8
7
6
5
4
3
2
1
0
(1)
(2)
(3)
(4)
(5)
(6)
78
79
80
81
82
83
84
85
86

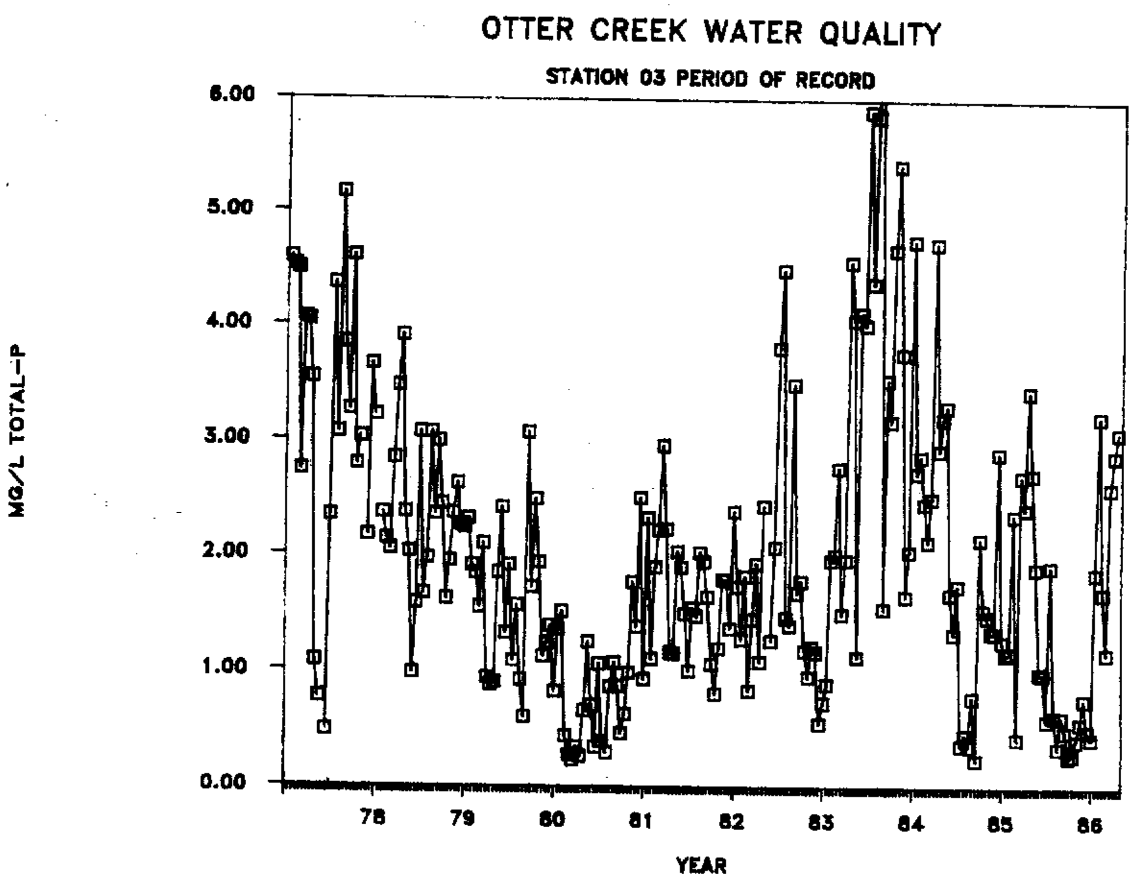
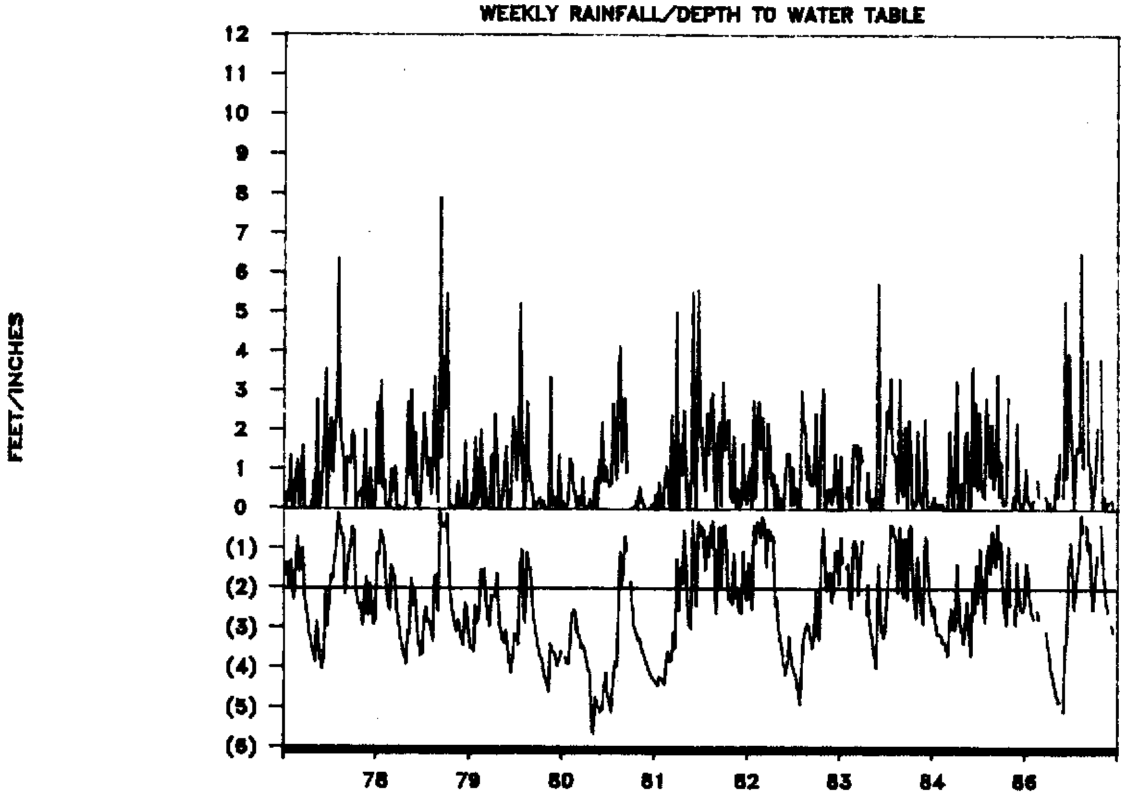

OTTER CREEK WATER QUALITY
STATION 03 PERIOD OF RECORD
MG/L TOTAL-P
6.00
5.00
4.00
3.00
2.00
1.00
0.00
78
79
80
81
82
83
84
85
86
YEAR

FIGURE 3. BASSETT 45.00 FT MSL

WEEKLY RAINFALL/DEPTH TO WATER TABLE



N.W. TAYLOR CREEK WATER QUALITY

STATION 01 PERIOD OF RECORD

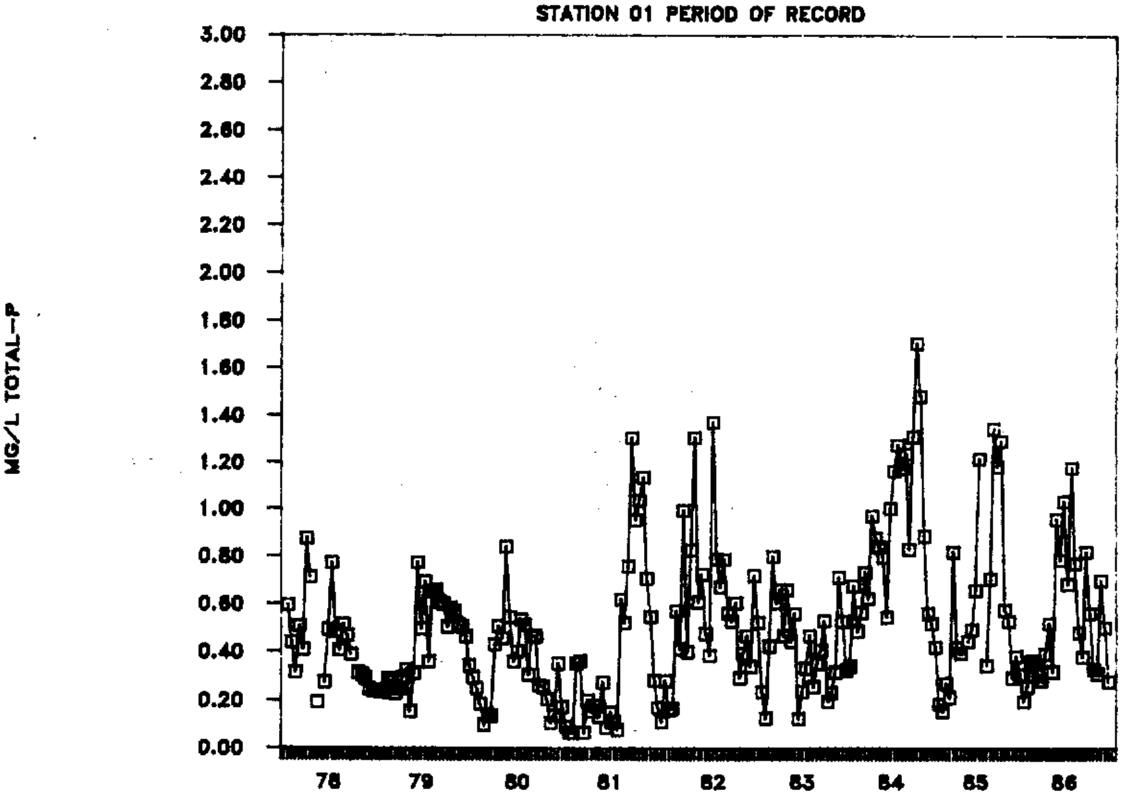
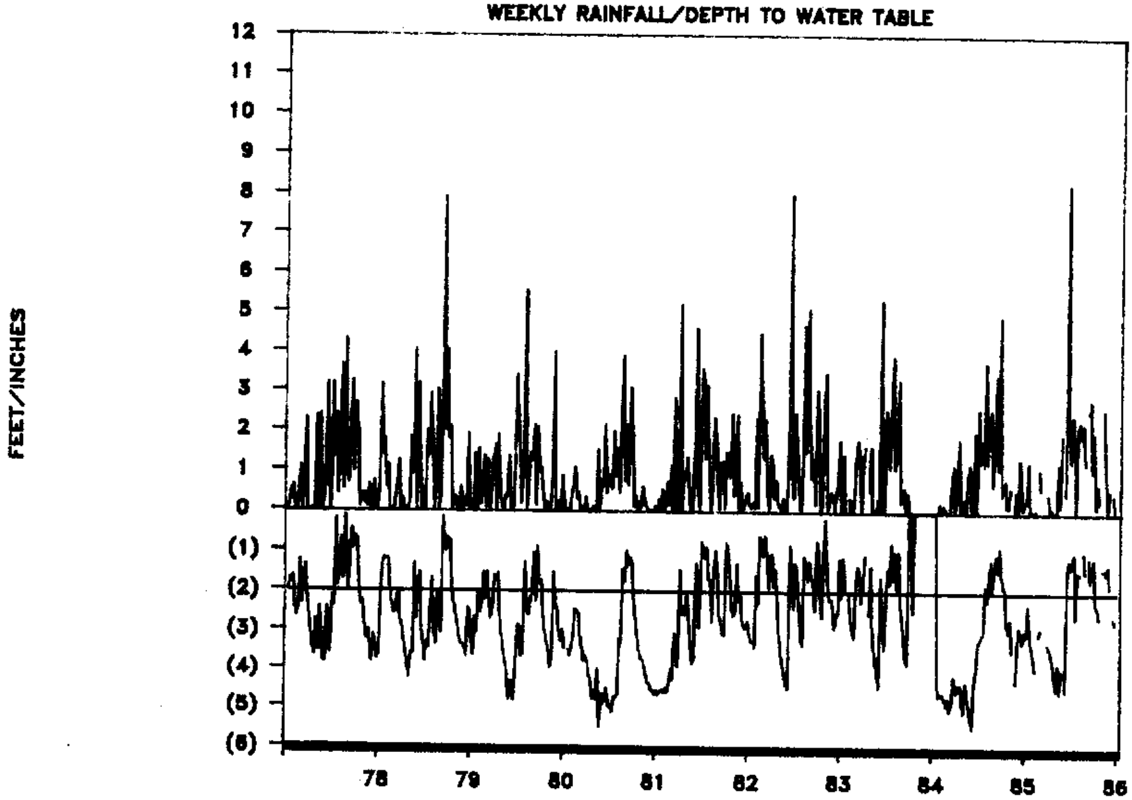


FIGURE 4. OPAL 35.26 FT MSL

WEEKLY RAINFALL/DEPTH TO WATER TABLE



WILLIAMSON DITCH STATION 08

TOTAL PHOSPHORUS CONCENTRATIONS

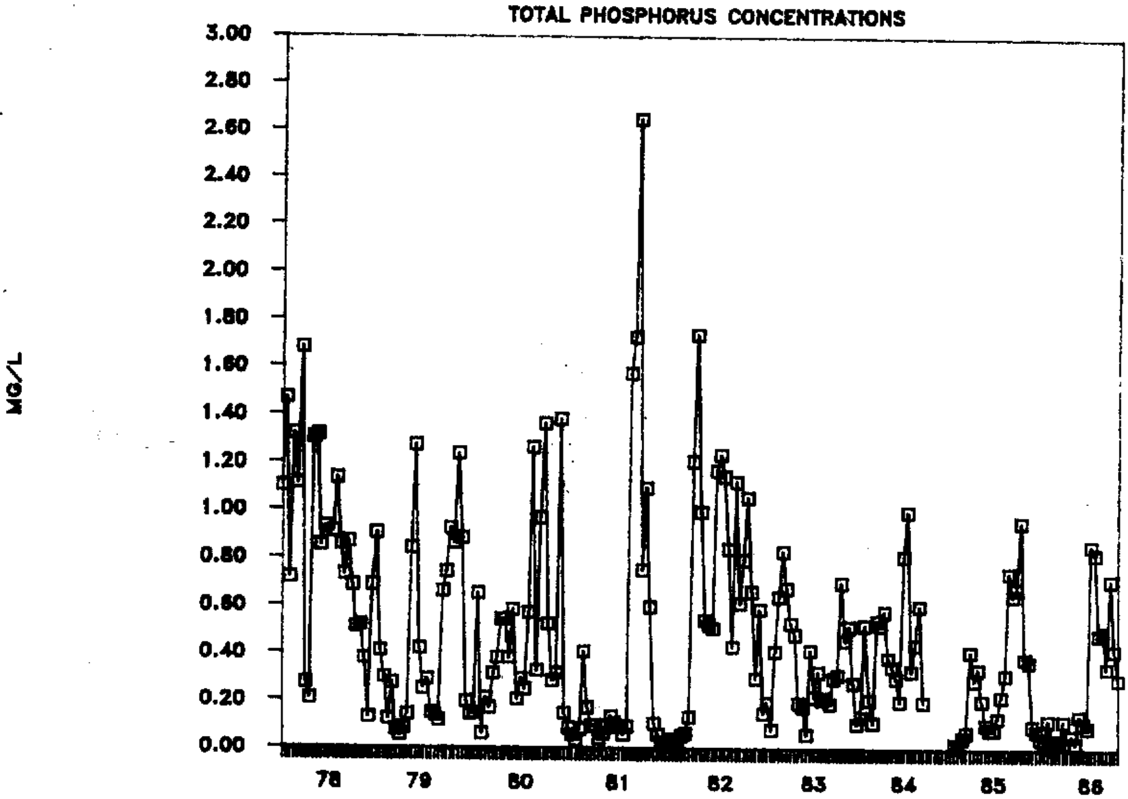
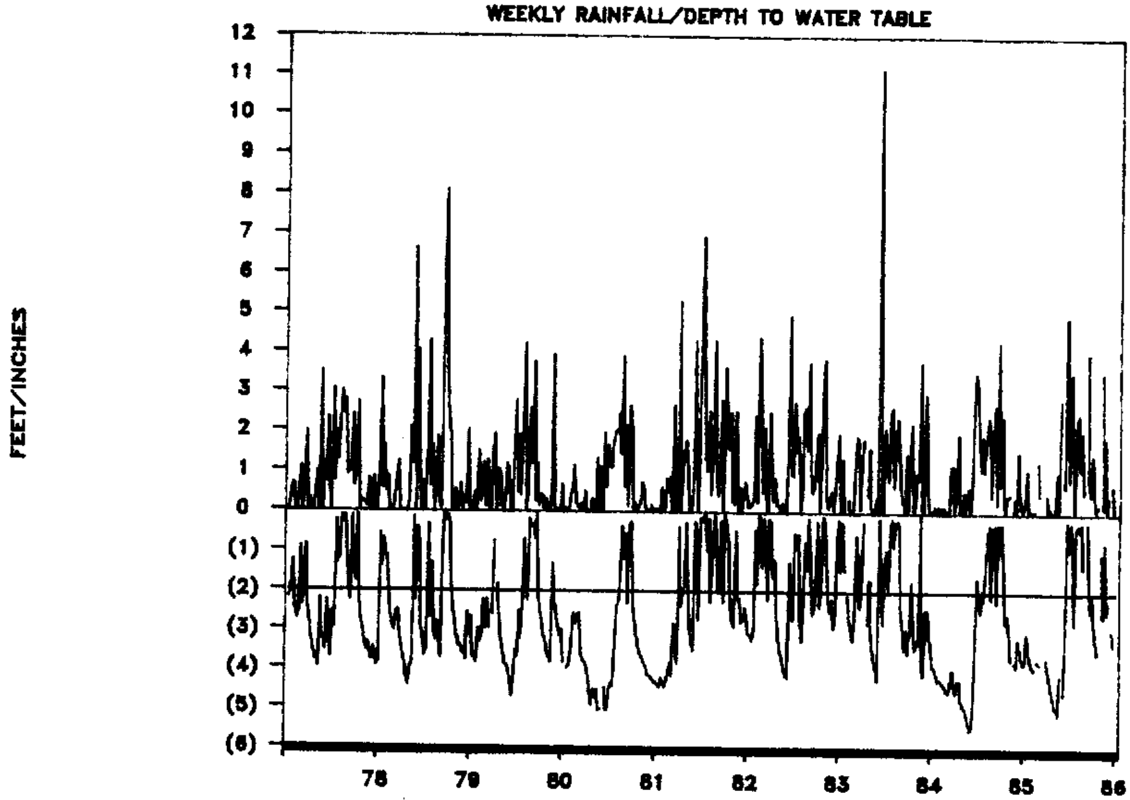


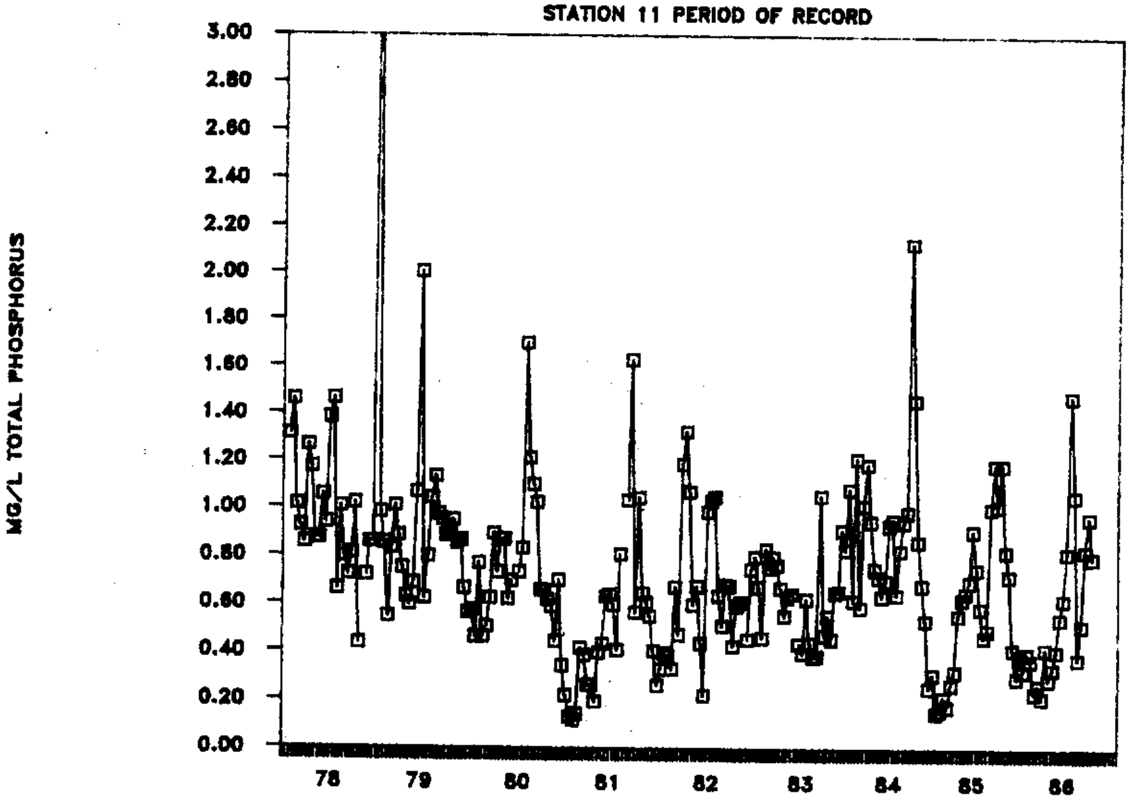
FIGURE 5. WELL LINE B 25.80 FT MSL

WEEKLY RAINFALL/DEPTH TO WATER TABLE



TAYLOR CREEK MAIN WATER QUALITY

STATION 11 PERIOD OF RECORD



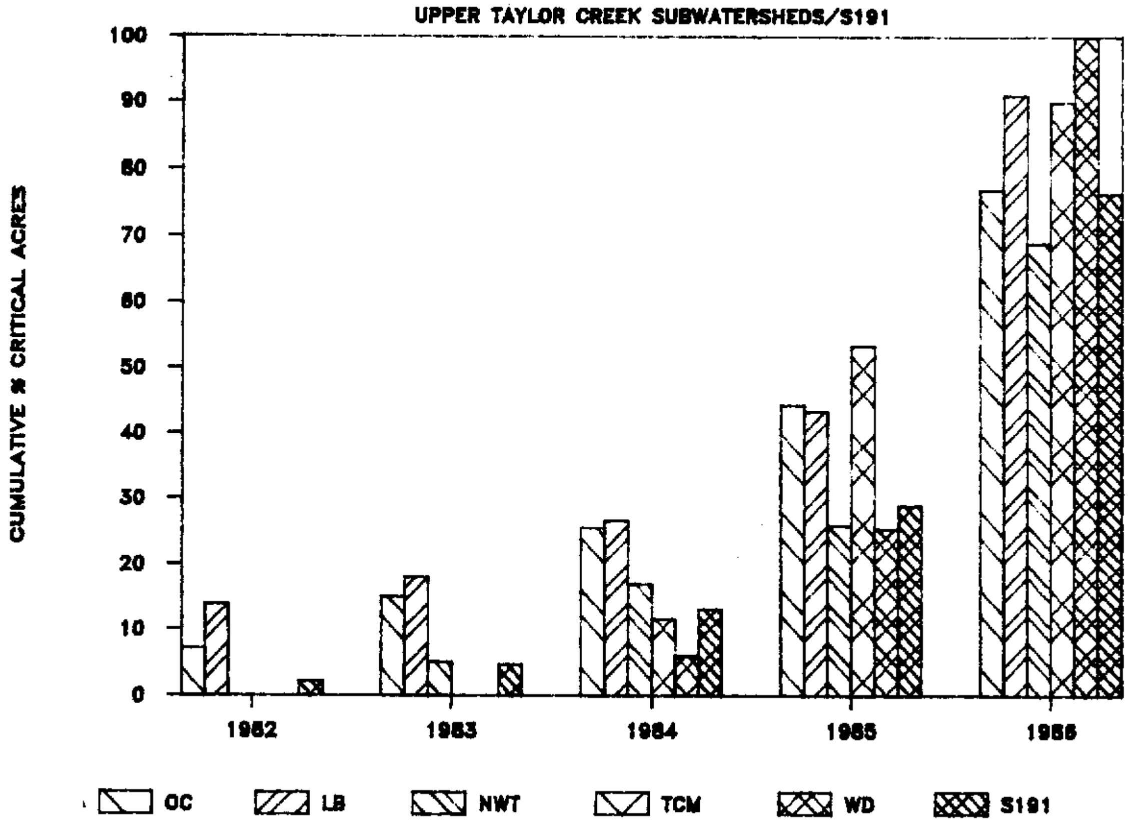
DATA ANALYSIS

Since the beginning of the Rural Clean Water Program (RCWP), evaluation of the water quality data has been limited to reporting annual means and wet season concentrations. Visual trends existing in either of these formats were evaluated on a sub-watershed scale based on existing conditions and changes observed in land use. By design this program has been divided into three phases (pre-, transition, and post-BMP) in order to adequately qualify the data base during each phase.

Currently, the program is moving out of the transition phase into the post-BMP phase (in the case of the Williamson sub-watershed, the program is three months into the post-BMP phase) . As of October, 78 percent of all prescribed BMPs have been implemented throughout the Taylor Creek/ Nubbin Slough watersheds. The percentage of BMP implementation, based on critical acres covered, for each of the nine major sub-watersheds {Otter Creek (OC), Little Bimini (LB), N.W. Taylor (NWT), Taylor Creek Main (TCM), Williamson Ditch (WD), Mosquito Creek (MC), Nubbin Slough (NS), Henry Creek (HC), and Lettuce Creek (LC)} is illustrated in Figure 6. The majority (greater than 40 percent) of BMP implementation throughout each of the sub-watersheds has occurred during 1986. For this reason, the water quality data base will probably not reflect more recent BMP implementation. Cumulative implementation of BMPs over time including a total basin percentage identified as S-191 is presented in Figure 7.

Because the program is now rapidly moving into the post-BMP phase, the general time series compilations in each of the sub-watersheds have exhibited some subtle changes. This year's analysis will incorporate a preliminary trend evaluation using the seasonal Kendall Tau test for significance. The results of this evaluation will be presented in their respective sub-watershed sections along with an explanation of the observed trend.

FIGURE 6. BMP IMPLEMENTATION



BMP IMPLEMENTATION

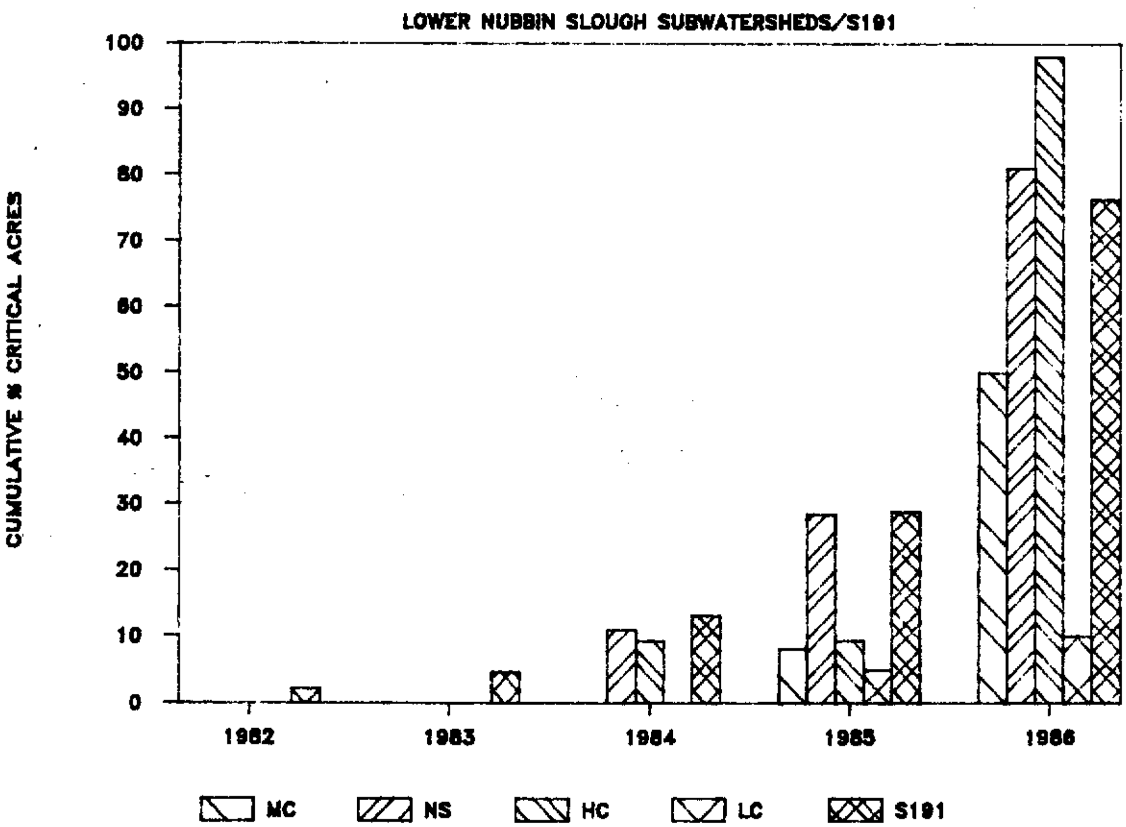
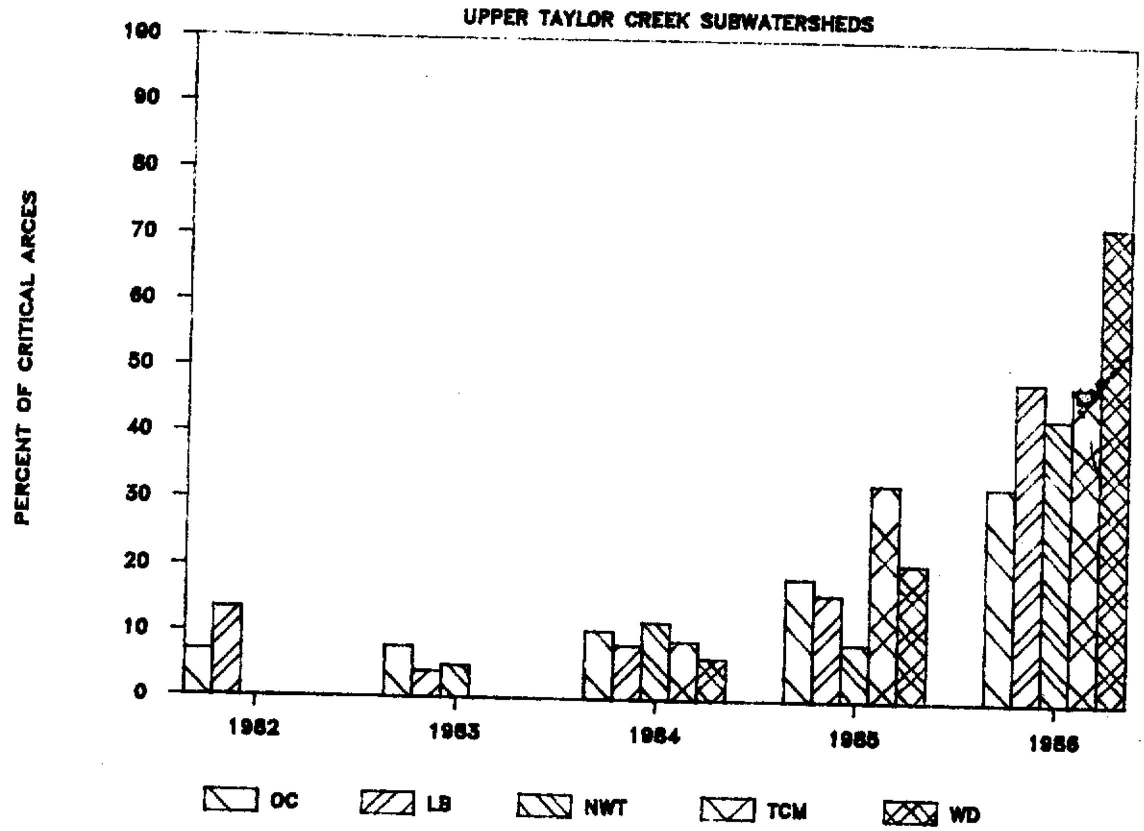
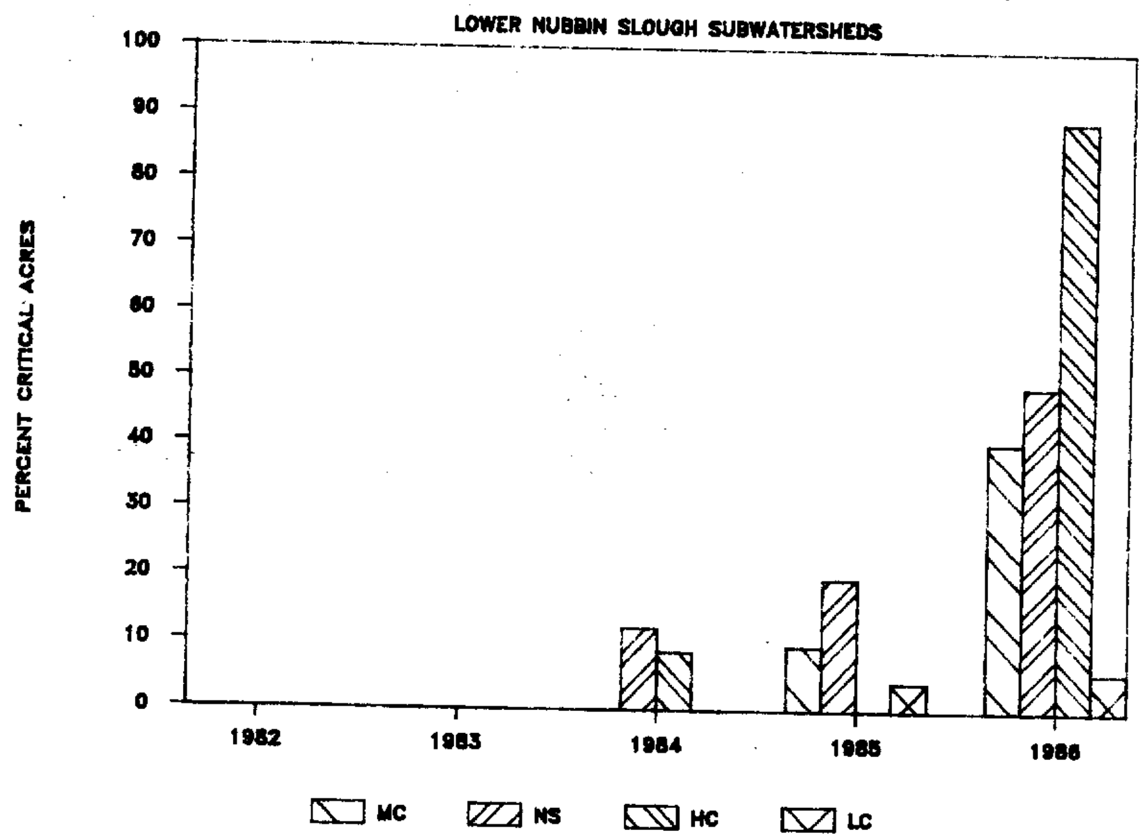


FIGURE 7. SUMMARY OF ANNUAL BMP IMPLEMENTATION



SUMMARY OF ANNUAL BMP IMPLEMENTATION

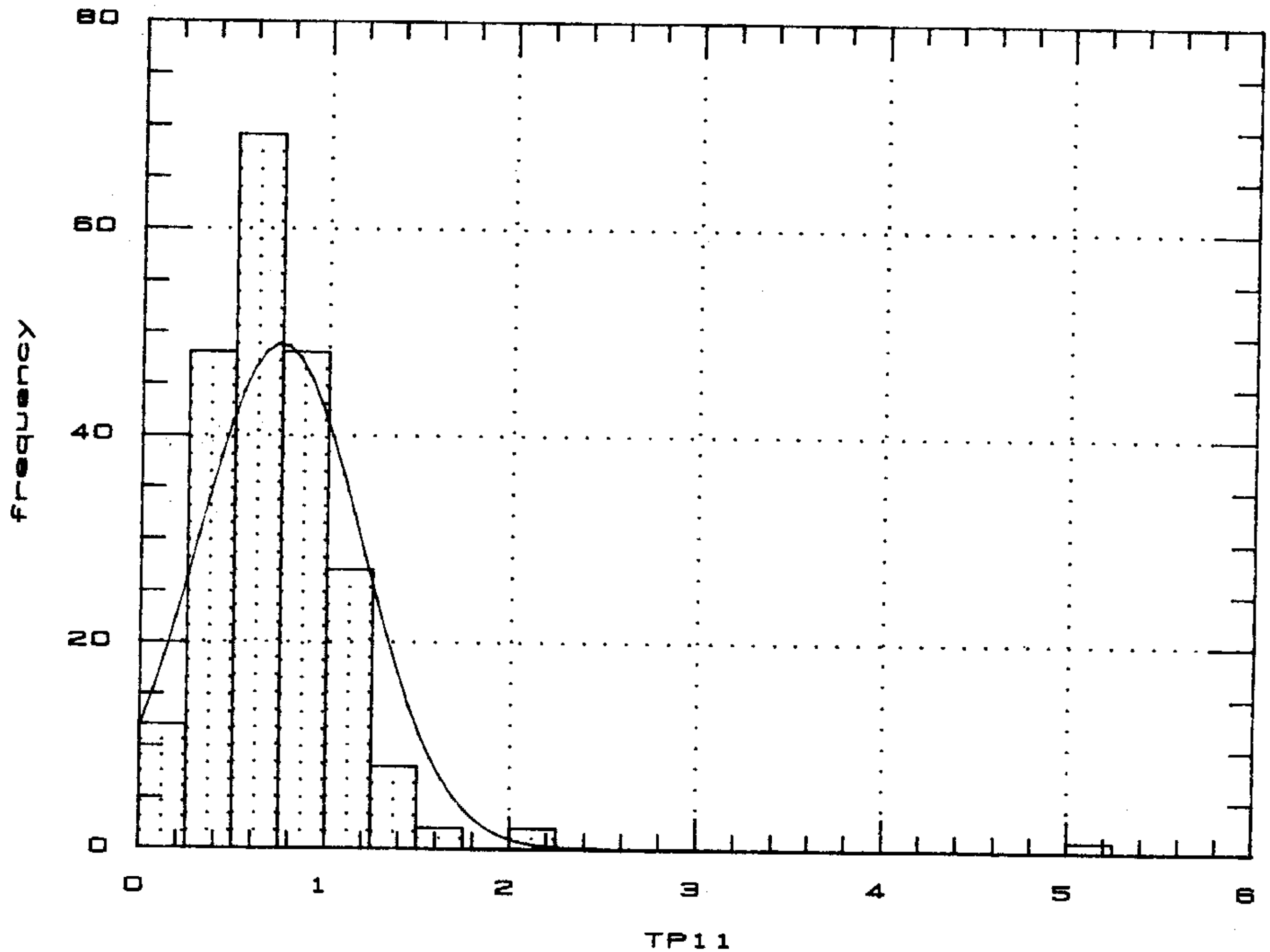


TREND ANALYSIS

A preliminary analysis was performed on phosphorus concentrations to determine if there has been a significant change for the period of implementation of BMPs. A non-parametric test for trend, the Seasonal Kendall test (Hirsch and Slack 1984, Hirsch et. al. 1982) was applied to the total phosphorus data from biweekly grab samples. The analysis is preliminary; the concentration data have not been corrected for variation in flow.

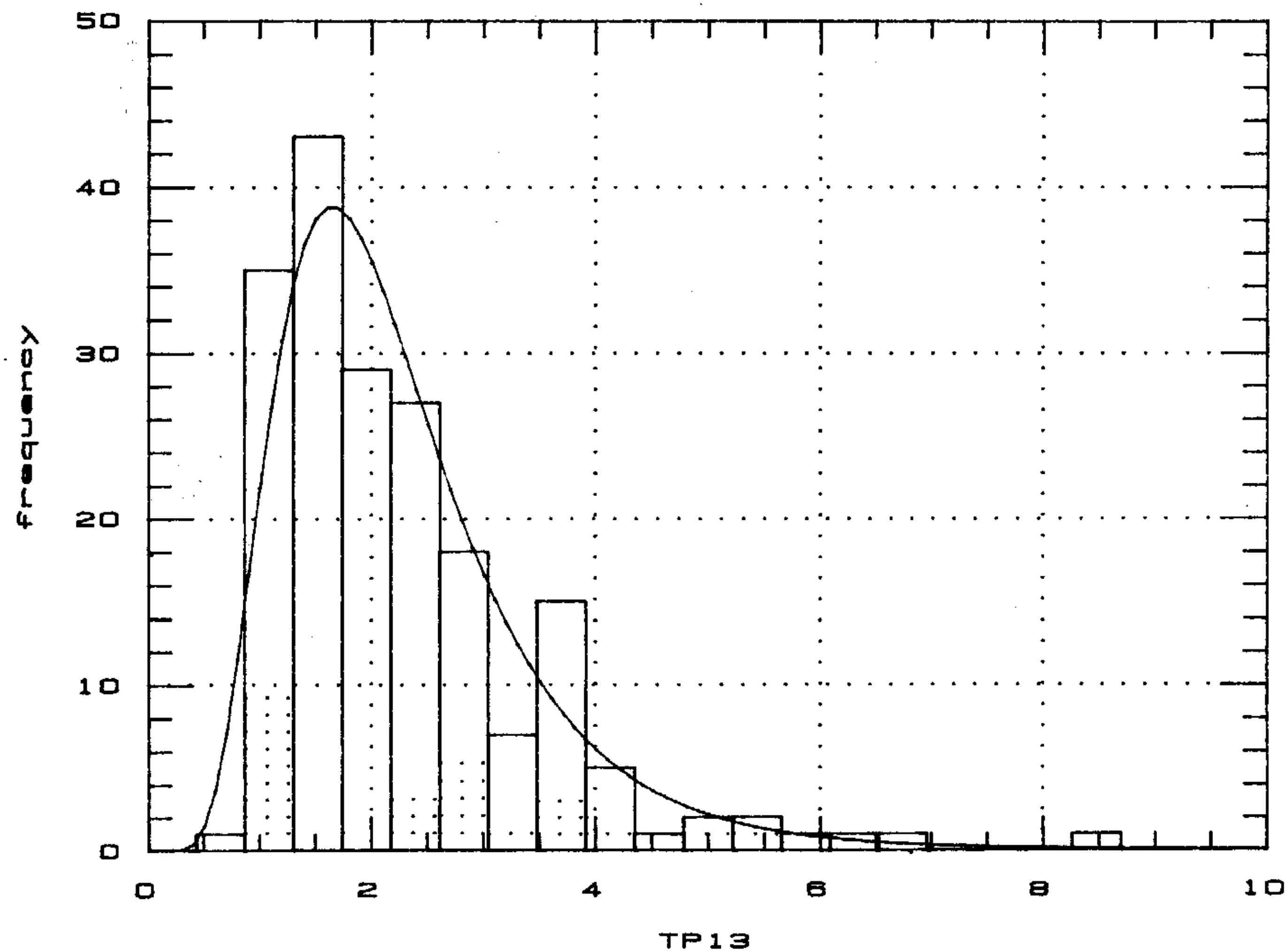
The seasonal Kendall Tau test is a non-parametric, seasonally adjusted trend evaluator that can be adjusted to be robust to serial correlation. A non-parametric method was selected due to the abnormal characteristic of the P concentration data. Typical frequency distributions are positively skewed with high peakedness (Figures 8 and 9), while Figure 10 depicts a more normal distribution. Distributions that exhibit positive skewness seem to occur at stations that do not have continuous flow. This exists in the small tributaries during the dry season when the flow is minimal or non-existant. Stations that exhibit more normal distributions are located in the main branch of Taylor Creek or in the case of S-191, the large L-63N interceptor canal. This situation provides for greater mixing and actually acts as a buffer diluting higher concentrated water generated from smaller upstream tributaries. Consequently, the larger volume of water passing through these stations tends to eliminate or minimize the occurrence of extreme outlier values. In the case of Figure 9, a single outlier value has caused this distribution to be positively skewed. Removing this outlier would create a cleaner statistical environment especially if the value cannot be explained. However, if the value is justified, it should not be removed despite the fact that it creates a lognormal situation in the data base. Although a lognormal distribution can be fitted to the

FIGURE 8. Frequency Histogram



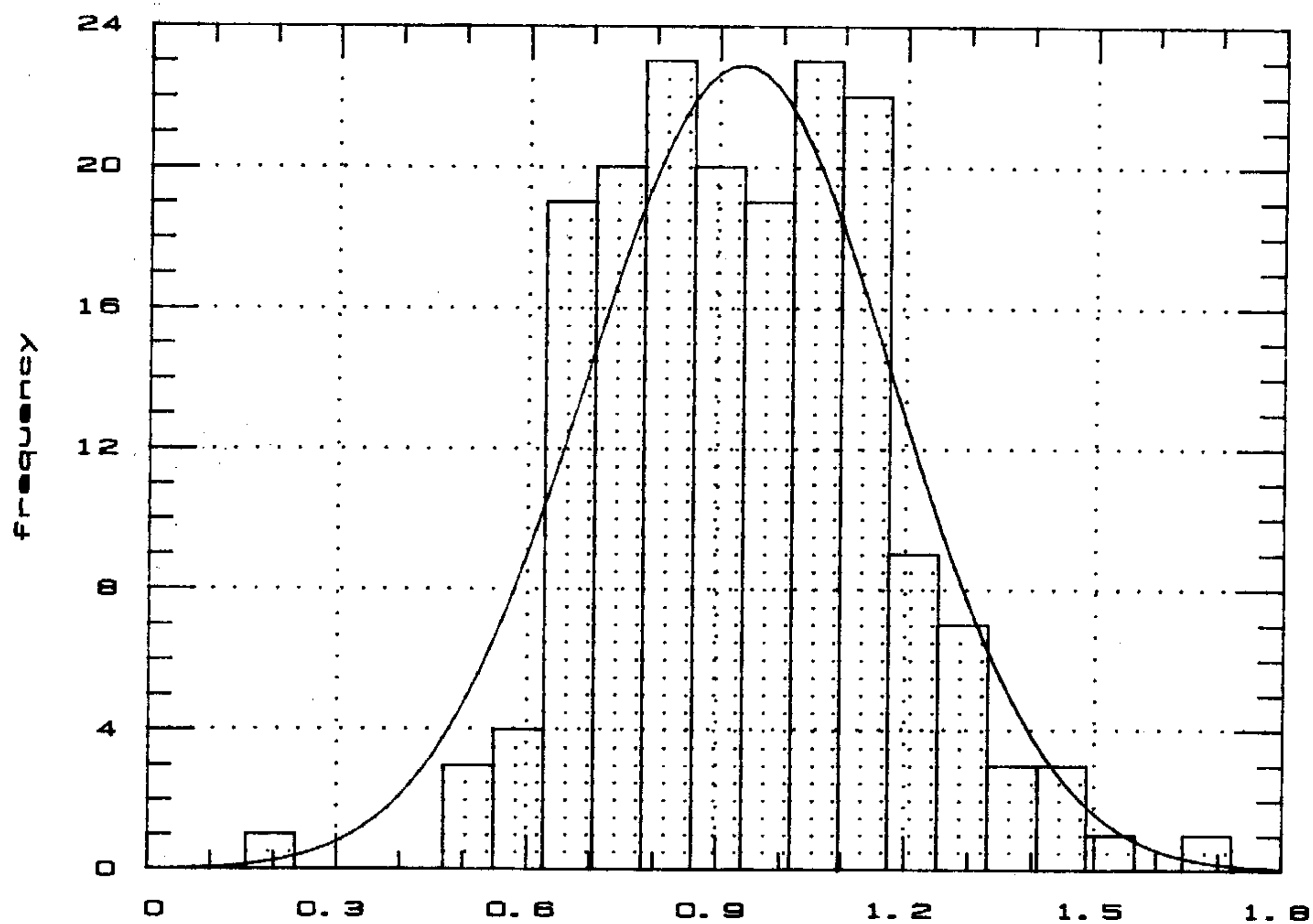
Concentration of Total-P at station 11

FIGURE 9. Frequency Histogram



Concentration of Total-P at station 13

FIGURE 10. Frequency Histogram



TP191
Concentration of Total-P at S-191

data, the empirical distribution is controlled by a few outlier values. Comparison in a non-parametric method provides robustness to outliers for the estimation of trend.

This Kendall Tau has been corrected for seasonal effects by Hirsch and Slack (1984). The year can be divided into 12 monthly seasons or 2 climatic seasons; the wet season (May 15 to October 15) and the dry season. The Kendall Tau then is calculated from comparisons of median P concentration values for each season over the period of record.

Mann Kendall test statistic:

$$S_g = \sum_{i<j} sgn(X_{jg} - X_{ig}) \quad g = 1, 2, \cdot \cdot \cdot , p$$

for p seasons and n years.

Seasonal Kendall test statistic:

$$S' = \sum_{g=1}^{p} S_g$$

The Tau values for each season are then averaged to determine the overall Tau.

This non-parametric test was also selected based on resistance to error introduced by strong time series dependence. Hirsch and Slack (1984) presented a method for accounting for the effect of serial dependence. Where long term persistence of an autocorrelative process (ARMA) may indicate the presence of trend, the test for trend must be adjusted. The adjustment is made to the estimation of the variance of the Seasonal Kendall test statistic. The test statistic is asymptotically normal with mean O and the following variance:

$$var\,[S'] = \sum_{g} \sigma_g{}^2 + \sum_{\substack{g,h \\ g \neq h}} \sigma_{gh}$$

The long term persistence is accounted for in the covariance term gh = cov (Sg. Sh). The covariance is added to the estimate of the variance to provide a measure of the normal variate. This effectively increases the Tau value required to obtain the same level of significance compared to the case where serial dependence does not occur.

A final criteria in selection of a non-parametric test is the type of test. There are two types of non-parametric tests available: a test for a step change in behavior and a test for long term trend. The trend test was selected for this analysis as the implementation of BMPs in the Taylor Creek/ Nubbin Slough basin has occurred over a period of years. The gradual implementation would make analysis as a step change difficult. In the situation where a dairy barn is shut down, e.g., Otter Creek, the effective change in water quality may be sufficiently abrupt to be analyzed as a step change.

However, since there are more years of pre-BMP data than transition period or post-BMP data, significant trends resulting from BMPs may be missed in this analysis. In the future, the data will also be analyzed by a form of non-parametric step change test.

Method

The time series of total phosphorus concentration data were analyzed for long term trend using the Seasonal Kendall Tau trend test corrected for serial correlation. This analysis was conducted using a series of FORTRAN routines developed by Slack (1985). The data was supplied in two fields as decimal time by year and concentration.

The trend test was conducted on data from 14 stations (Figure 11) for a period of record from 1978 to present (Table 1). In successive tests at each station, the data were stratified into 26, 23, 8, 4, and 2 seasons for each year based on either the calendar year or a seasonal year. The seasonal year began May 15, which is the approximate beginning of the yearly wet season.

Results of the trend analysis for water quality stations that exhibited a significant change in total phosphorus concentrations are presented in Table 2.

FIGURE 11 TAYLOR CREEK/NUBBIN SLOUGH WATERSHED TREND TEST STATIONS

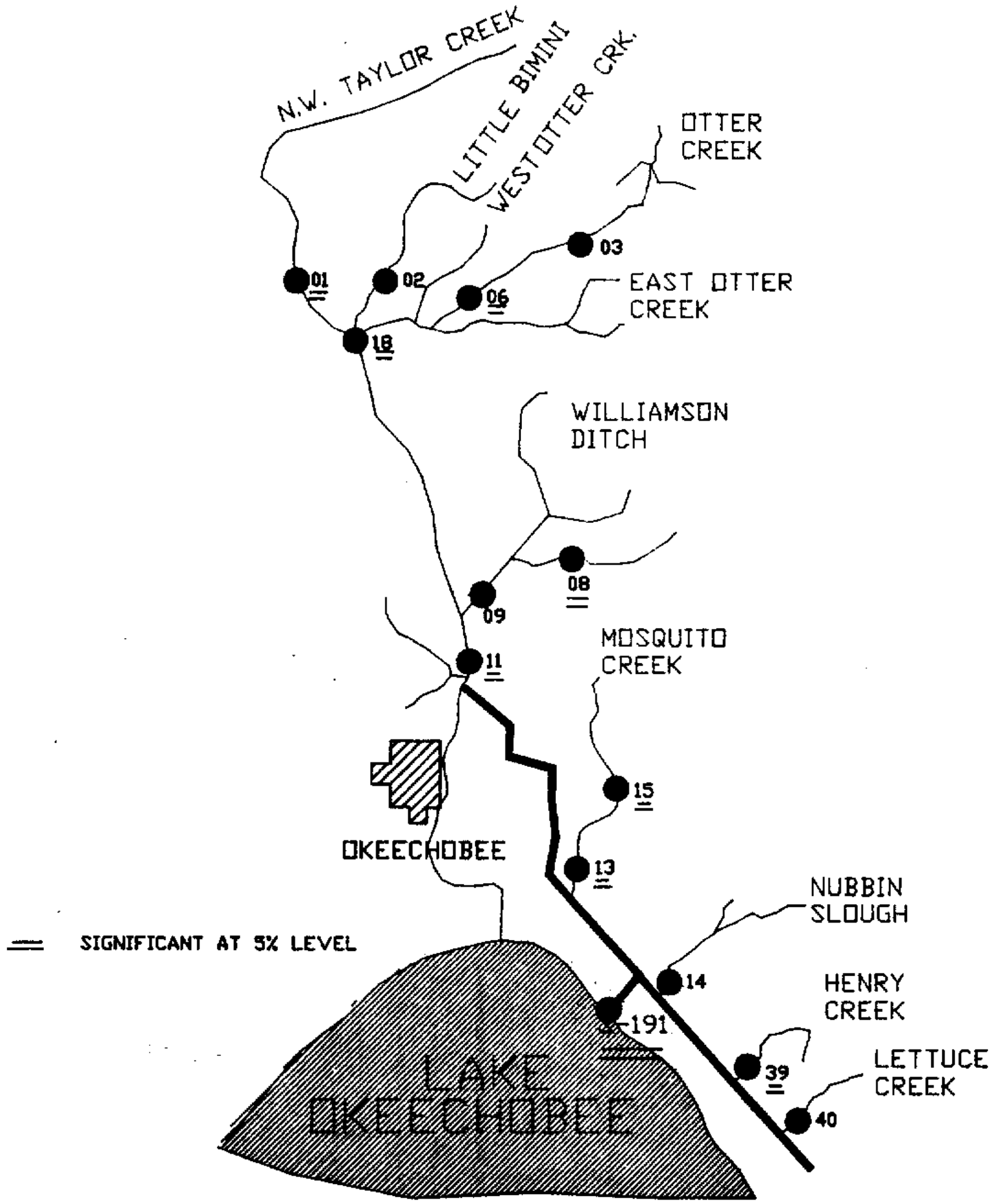


TABLE 1. IDENTIFICATION OF TREND TEST STATIONS

Water Quality Stations	Location		Trend
Station 01	NW Taylor Creek	Significant	Increasing
Station 02	Little Bimini	Not Significant	No Change
Station 03	Upstream Otter Creek	Not Significant	No Change
Station 06	Downstream Otter Creek	Significant	Decreasing
Station 08	Williamson East Lateral	Significant	Decreasing
Station 09	Downstream Williamson	Not Significant	No Change
Station 11	Upper Taylor Creek	Significant	Decreasing
Station 13	Downstream Mosquito Creek	Significant	Decreasing
Station 15	Upstream Mosquito Creek	Significant	Decreasing
Station 14	Downstream Nubbin Slough	Not Significant	No Change
Station 18	Headwater Confluence	Significant	Decreasing
Station 39	Henry Creek	Significant	Increasing
Station 40	Lettuce Creek	Not Significant	No Change
Station S-191	Lake Okeechobee	Significant	Decreasing

TABLE 2. RESULTS OF TREND ANALYSIS FOR SELECTED WATER QUALITY STATIONS IN TAYLOR CREEK/ NUBBIN SLOUGH EXHIBITING A SIGNIFICANT CHANGE IN TOTAL PHOSPHORUS

Station	Seasonal Kendall Tau	Probability Level		Trend
		WOS	WS	[TP] / YR
01	0.273	0.0007	0.07	0.033
06	-0.446	0.0000	0.014	-0.27
08	-0.36	0.0000	0.0091	-0.0508
11	-0.265	0.0008	0.025	-0.034
13	-0.234	0.005	0.11	-0.096
15	-0.291	0.0004	0.054	-0.131
18	-0.322	0.0014	0.032	-0.07
39	0.259	0.027	0.19	0.203
S-191	-0.452	0.0000	0.014	-0.048

NOTE: WOS - PROBABILITY CALCULATED WITHOUT ADJUSTMENT FOR SERIAL CORRELATION. S - PROBABILITY WITH SERIAL CORRELATION.

Descriptive variables for each of these stations are listed in Table 3.

TABLE 3. DESCRIPTIVE VARIABLES OF WATER QUALITY STATIONS THAT EXHIBITED A SIGNIFICANT CHANGE IN TOTAL PHOSPHORUS CONCENTRATIONS

Variable	Station		
	01	06	18
Sample Size	209	199	139
Average	0.51	2.19	0.95
Median	0.46	2.01	0.80
Standard Deviation	0.32	1.15	0.59
Minimum	0.06	0.40	0.06
Maximum	1.71	5.86	3.21
Skewness	1.15	0.51	1.31
Kurtosis	1.15	-0.27	2.30
K-S Significance*	0.0082	0.31	0.041
Variable	Station		
	08	13	15
Sample Size	206	189	198
Average	0.47	2.27	2.14
Median	0.33	1.97	1.78
Standard Deviation	0.43	1.19	1.43
Minimum	0.01	0.86	0.15
Maximum	2.65	8.61	12.96
Skewness	1.45	1.82	3.04
Kurtosis	2.84	5.08	16.96
K-S Significance*	0.0004	0.01	0.0005
Variable	Station		
	11	39	S-191
Sample Size	217	123	180
Average	0.74	2.41	0.93
Median	0.67	1.84	0.93
Standard Deviation	0.44	1.87	0.25
Minimum	0.12	0.17	0.00
Maximum	5.03	10.78	1.67
Skewness	4.53	1.80	-0.36
Kurtosis	40.04	3.62	1.90
K-S Significance*	0.0035	0.0009	0.999

*KS SIGNIFICANCE: SIGNIFICANCE LEVEL AT WHICH THE OVERALL KOLMOGOROU-SMIRNOU GOODNESS - OF FIT TEST INDICATES THAT THE EMPIRICAL DISTRIBUTIONS ARE DIFFERENT FROM THE NORMAL DISTRIBUTIONS

Significant trends in water quality at the 5 percent level were detected at nine of the 14 stations (Figure 11). Of these nine stations the long term TP concentrations were found to decrease at seven stations. These trends were significant without considering serial dependence. Where corrected for covariance, only data at three stations showed significant trends at the 5 percent level (06, 13, 15). Finally, only one site had a significant trend at the 1 percent level. This occurred at station 6 on Otter Creek where a dairy barn shut down occurred in fall 1981. This resulted in a substantial decrease in TP concentrations.

In computing the test statistic selection of the seasons for stratifying the data affects both the significance level and trend estimate. The calculated significance levels were lower where more seasons were considered and the seasons adjusted to coincide with the wet season-dry season behavior. The effect of the greater number of seasons may reflect a more detailed representation of seasonal change and a more accurate description of the serial dependence. The estimated values for trend slope varied arbitrarily with number of seasons. The probability levels were higher for all calculations when the serial dependence was considered.

DISCUSSION OF WATER QUALITY DATA BY SUB-WATERSHED

Otter Creek

General Information - Critical Acres - 10,753

	Land Use	Acres	% Critical Acres
1			
	Dairy	6,518	61
	Beef	4,235	39
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 9	931	6,400
	Beef - 8	529	1,000
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	26 Upstream	Biweekly
		03 Intermediate	Biweekly
		06 Downstream	Biweekly
		19	Biweekly
	Runoff Grab	25	Biweekly
		27	Biweekly
		20	Biweekly

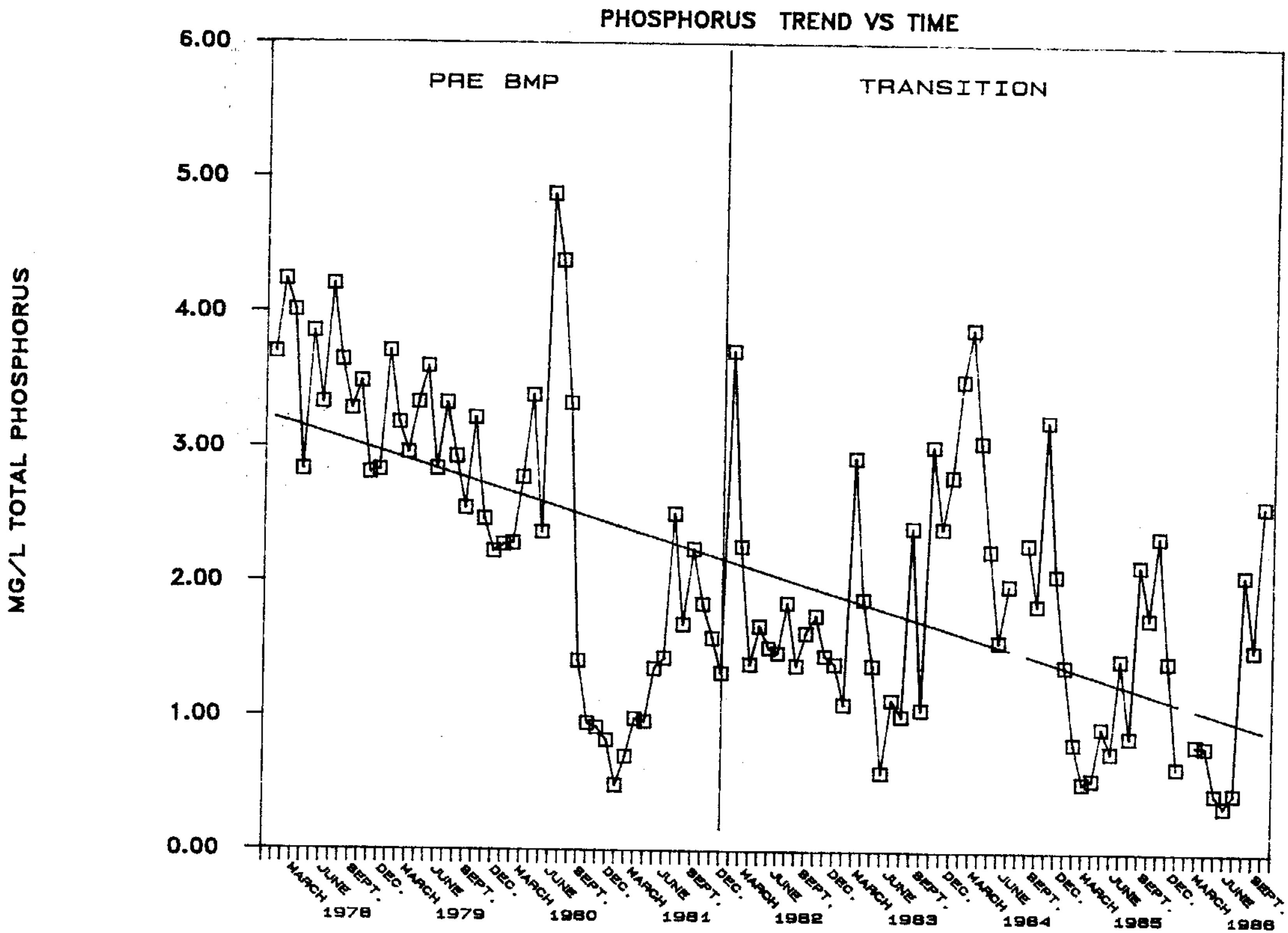
Time series trends of wet season total and ortho phosphorus, total and inorganic nitrogen concentrations for Stations 03 and 06 upstream and downstream, respectively, are presented in Appendix I. A summary of 1985 and 1986 annual means, minimum, and maximum values for the remaining sites are also presented in Appendix I.

Discussion

As of October 30, 1986, 77 percent of prescribed BMPs were implemented throughout the critical area of Otter Creek (10,753 acres). Presented in Figure 12 is the total phosphorus trend over time generated from the seasonal Kendall Tau analysis. This test was conducted on data from station 03 and station 06 in Otter Creek. Station 06 (downstream) total P concentration data had a significant (at the 5 percent level) downward trend while data from the upstream station 03 showed no significant trend.

Much of the improvement in total phosphorus concentrations observed at station 06 can be attributed to the shutdown of F and R Dairy in September of 1981. This

FIGURE 12. OTTER CREEK DOWNSTREAM STATION 06



operation was changed from a highly intensive dairy system to a very low density beef operation (less than one cow per three acres).

Total phosphorus concentrations at station 03 have yet to show any significant improvement due to continued surface water runoff from upstream dairy operations (Figure 13). Future plans for existing drainage from high intensity pastures as to reroute flows back into detention areas. The majority of the prescribed BMPs implemented throughout the Otter Creek sub-watershed have been fencing, diversion, and waste water utilization (i.e., spray irrigation and wash water recycling). With additional emphasis placed on diversion of high intensity runoff from pastures upstream of station 03, water quality at this site should begin to exhibit some improvement.

Little Bimini

General Information - Cricital Acres 4,050

1	Land Use		Acres	% Critical Acres
	Dairy		2,903	72
	Beef		1,128	27.5
	Hog		19	0.5
2	Farms		Average Acres	Approx. Animal Units
	Dairy - 3		968	3,800
	Beef - 6		188	480
	Hog - 1		19	75
3	Water Quality Sampling Sites		Site #	Sampling Frequency
	Open Channel Grab	02	Upstream	Biweekly
		104	Downstream	Biweekly

Time series trends of wet season total and ortho phosphorus, total and inorganic nitrogen concentrations for stations 02 and 104 are presented in Appendix I. A summary of 1985 and 1986 annual means, minimum, and maximum values for the remaining sites are also presented in Appendix I.

Discussion

As of October 30, 1986, 91 percent of the prescribed BMPs were implemented throughout the critical area of Little Bimini (4,050 acres) Figure 14. The seasonal

FIGURE 13. OTTER CREEK WATER QUALITY

UPSTREAM DOWNSTREAM AND MCARTHUR #1

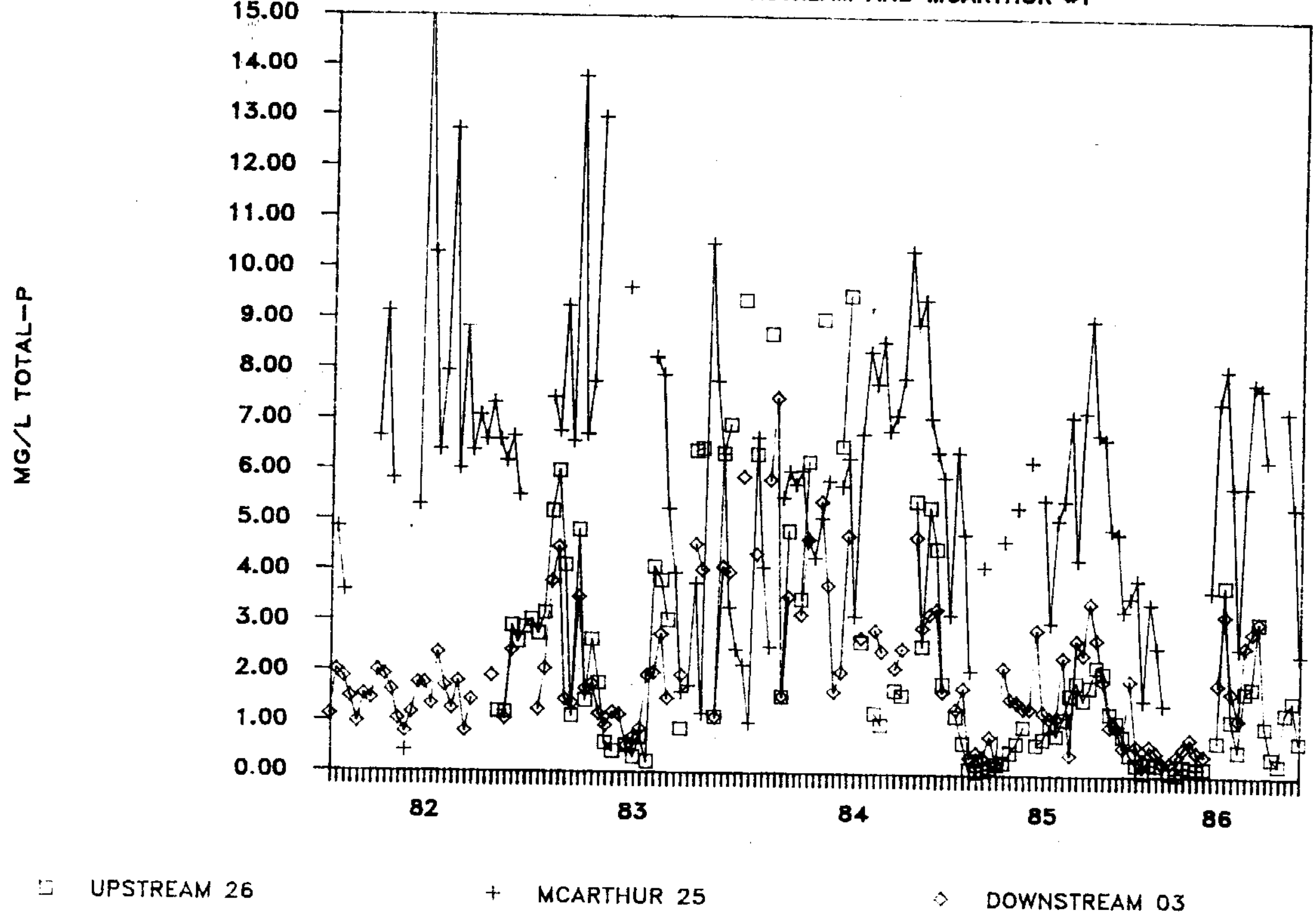
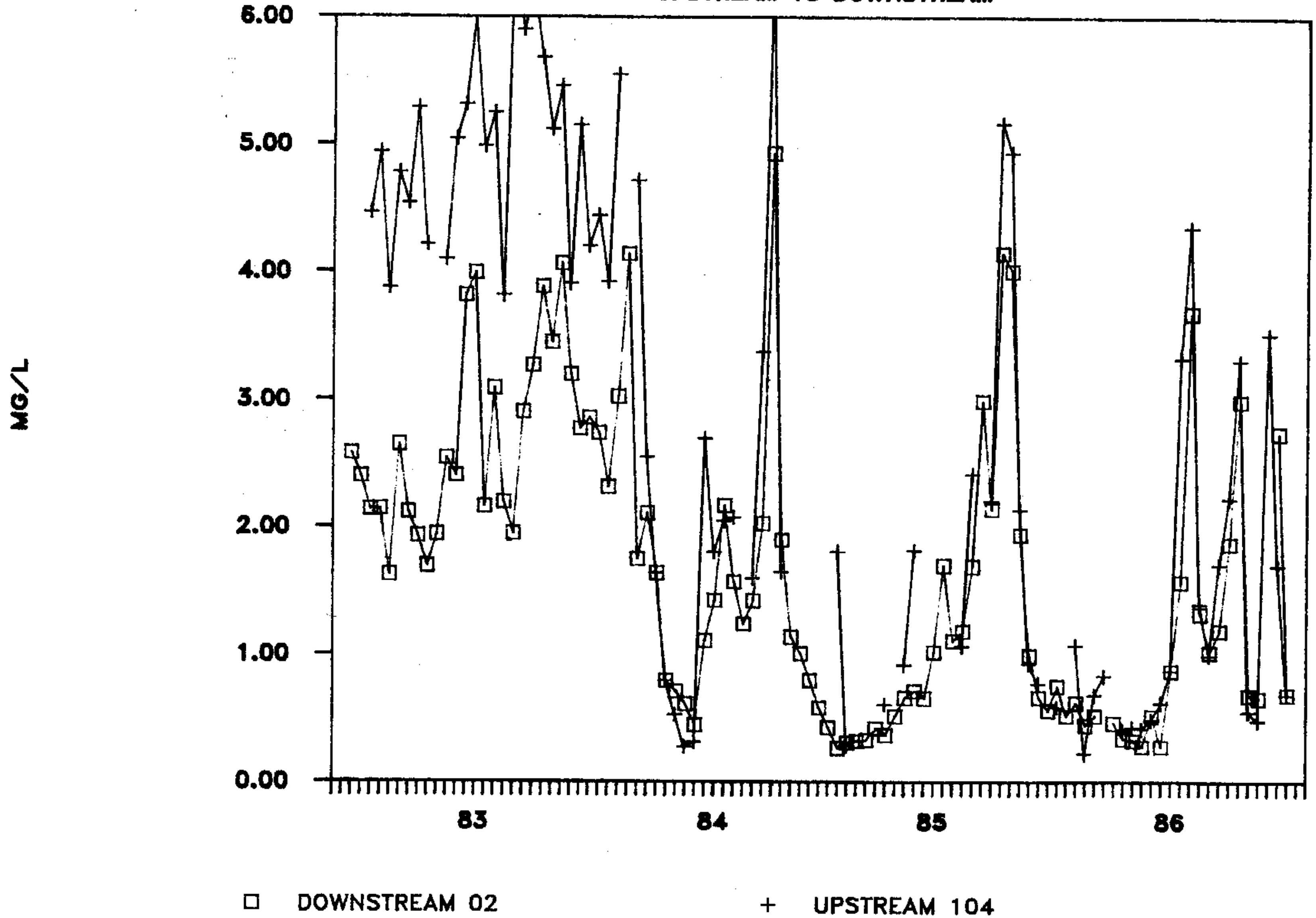


FIGURE 14. LITTLE BIMINI TOTAL PHOSPHORUS

UPSTREAM VS DOWNSTREAM



Kendall Tau test for trend significance was performed using data from the downstream water quality station (02) in Little Bimini. At this time there was no indication of any increasing or decreasing trends in total phosphorus concentrations. Improvement of existing phosphorus concentrations will depend a great deal on our ability to handle pasture runoff from the high intensity areas located in the headwaters drainage of Little Bimini. In addition to the fencing that has been performed along these high intensity areas, diversion of runoff also needs to be addressed to improve surface water quality. The results of the Kendall Tau test can be substantiated by examining the time trend of wet season concentrations at station 02. This illustration is provided in Appendix I.

N. W. Taylor Creek

General Information - Critical Acres 11,865

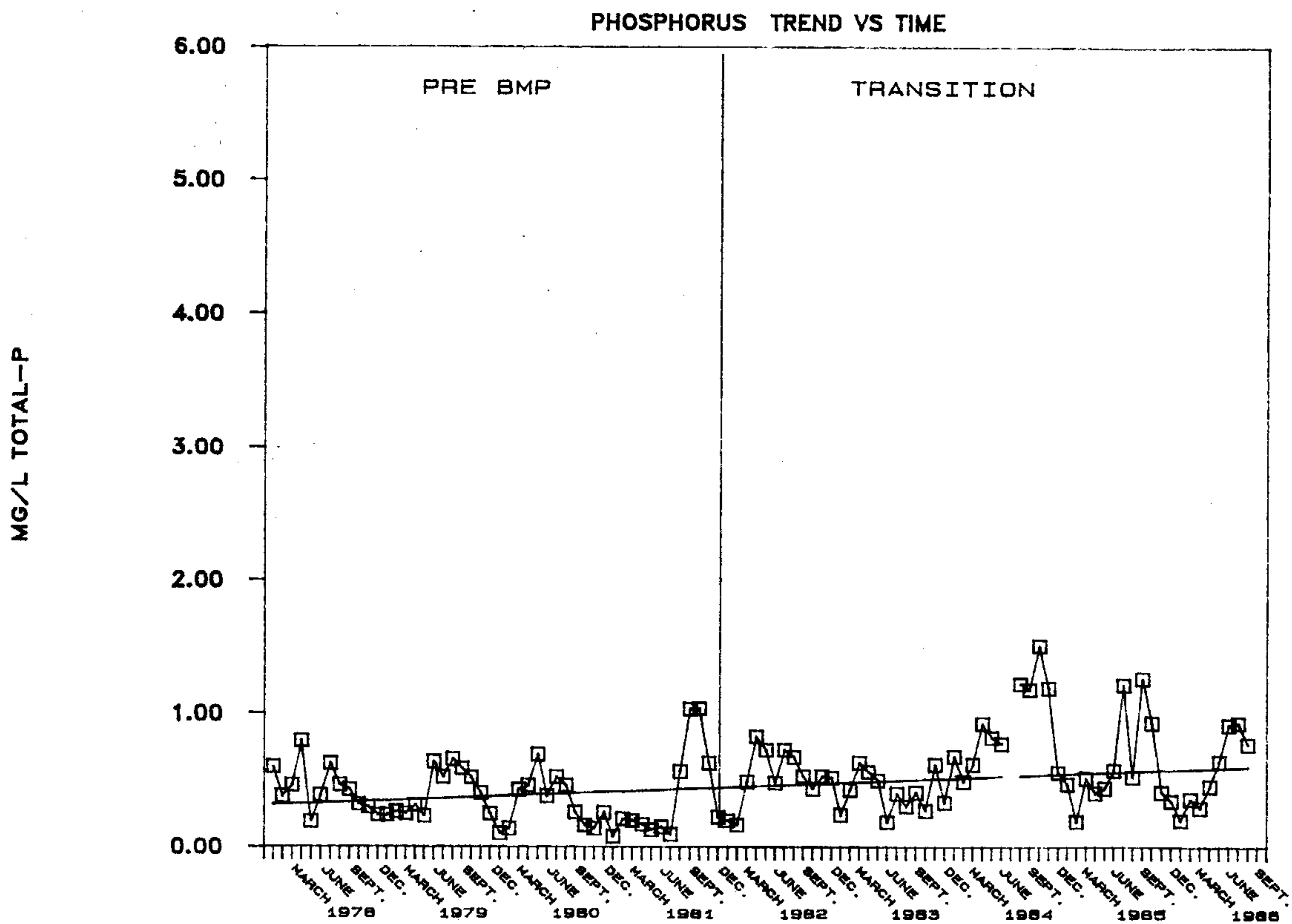
1	Land Use	Acres	% Critical Acres
	Dairy	9,142	77
	Beef	1,813	15
	Citrus	910	8
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 1	9,142	6,500
	Beef - 1	1,813	600
	Citrus - 1	910	
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	01	Biweekly

Presented in Appendix I are time series trends of wet season total and ortho phosphorus and total and inorganic nitrogen concentrations for station 01. Mean, minimum, and maximum values for selected parameters during 1985 and 1986.

Discussion

There has been a slight increase in total phosphorus in the N.W. Taylor Creek sub-watershed. Although 90 percent of the prescribed BMPs have been implemented, results of the Kendall Tau test suggest that there is a slight, but significant trend, over the last eight years (Figure 15). The upward trend may be a

FIGURE 15. N.W.TAYLOR CREEK STATION 01



response to the expansion of a large cow/ calf operation during 1981. The water quality has yet to respond to the primary BMP, fencing cows out of the stream.

Headwaters Summary

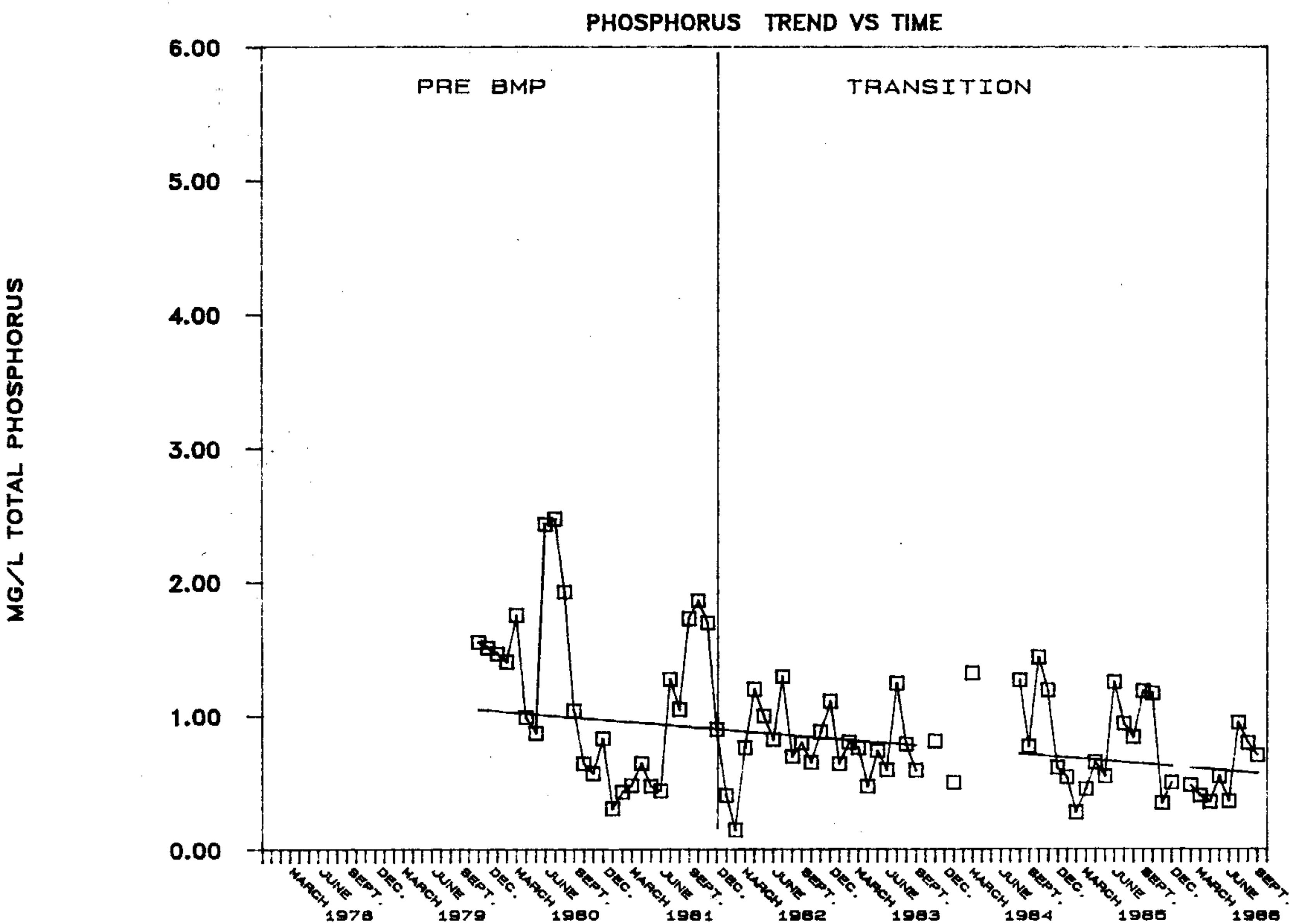
The headwaters of the upper Taylor Creek Basin is represented by input from three tributaries, Otter Creek, Little Bimini, and N. W. Taylor Creek. The major tributaries throughout the headwaters are complete in terms of implementation of the fencing component of the program. Water quality station 18 is located at the confluence of these three tributaries and represents the sum of land use changes in these three sub-watersheds. Results of the Kendall Tau test at station 18 indicate a slight improvement in total phosphorus concentrations from 1979 through 1986 (Figure 16). Events point toward the shutdown of F and R Dairy as the major influence on these downstream concentrations at station 18. Results from Little Bimini and N. W. Taylor Creek, two sub-watersheds that have yet to exhibit any improvement, substantiate the dairy shutdown conclusion due to the significant water quality improvements observed in Otter Creek. Wet season nutrient concentrations presented in Appendix I substantiate the results of the Kendall Tau test exhibiting a decreasing trend in total phosphorus concentrations.

Taylor Creek Main

General Information - Critical Acres 6,464

1	Land Use		Acres	% Critical Acres
	Dairy		2,765	42.5
	Beef		3,694	57
	Hog		5	.5
2	Farms		Average Acres	Approx. Animal Units
	Dairy - 1		922	2,500
	Beef - 6		616	1,500
	Hog - 1		5	100
3	Water Quality Sampling Sites		Site #	Sampling Frequency
	Open Channel Grab	18	Upstream	Biweekly
		12	Intermediate	Biweekly
		11	Downstream	Biweekly

FIGURE 16. TAYLOR CRK. HEADWATERS STATION 18



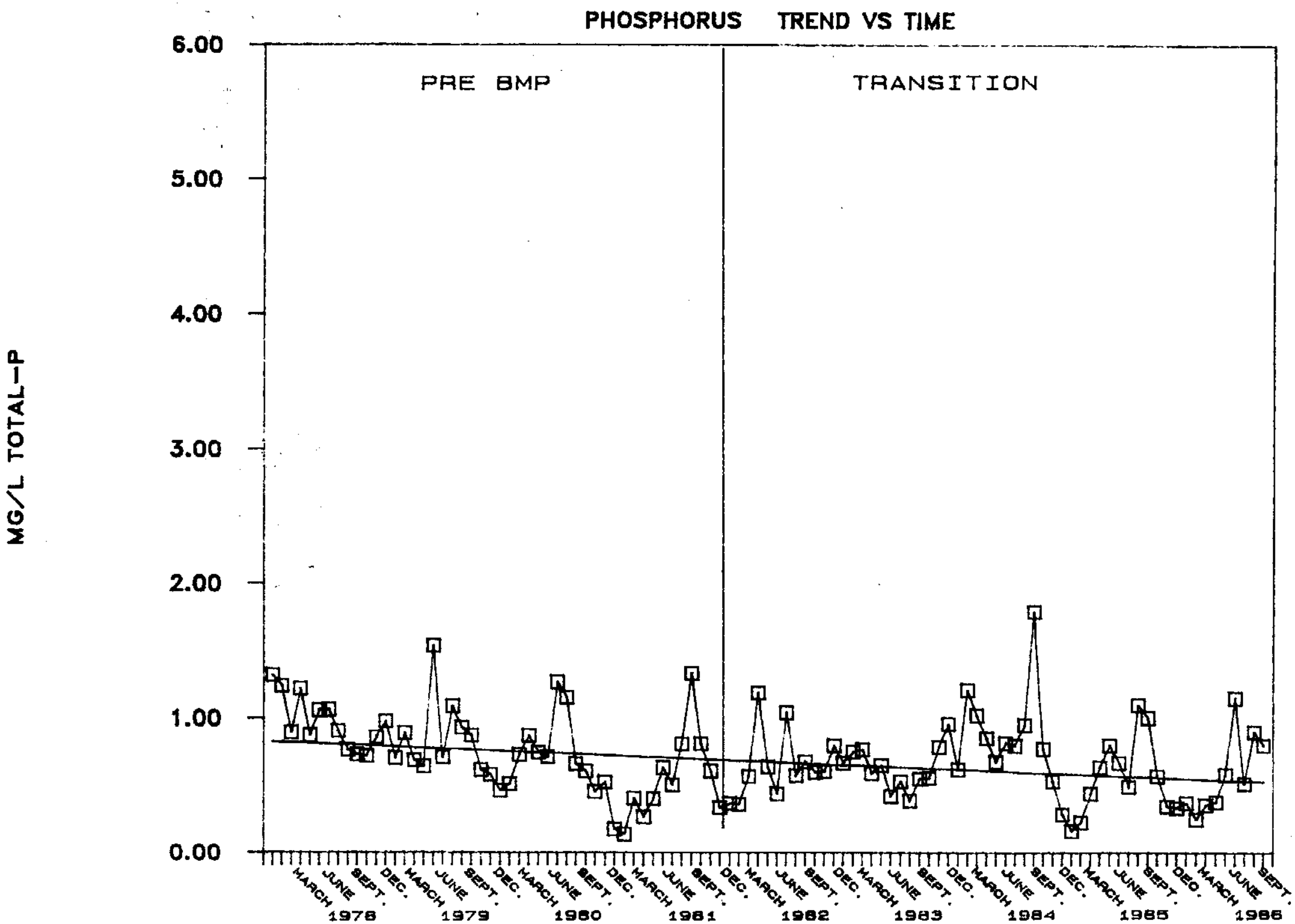
Time series trends of wet season total phosphorus ortho phosphorus and total and inorganic nitrogen are presented in Appendix I for stations 18 and 11. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 are also presented in Appendix I for stations 18, 12, and 11.

Discussion

The water quality appears to have improved for Upper Taylor Creek. The outflow of this area, and the entire upper Taylor Creek watershed is represented at station 11 (Figure 17). The Kendall Tau test for station 11 indicates a slight decreasing trend in total phosphorus concentrations from 1978 to present. This trend also exists in the wet season time series for total phosphorus and total nitrogen concentrations. Much of the improvement observed at station 11 may, however, be directly attributed to the improvement in water quality exhibited at the headwaters station 18 where mean annual total phosphorus concentrations have decreased 50 percent from 1978 through 1986.

Much of the BMP implementation throughout the main branch of Taylor Creek has been to fence cows out of the major water course and tributary drainage. Ninety-one percent of the prescribed BMPs have been implemented over the critical area surrounding the main branch of Taylor Creek. Due to low beef cow densities around Taylor Creek Main, much of the BMP implementation, dealing with dairy effluent and the high intensity dairy pasture runoff, in the headwaters area will have a greater initial impact on the improvement of water quality at the stations along Taylor Creek Main. In contrast, the impact of fencing on water quality throughout Taylor Creek Main will be more subtle.

FIGURE 17. TAYLOR CREEK MAIN STATION 11



Williamson Ditch

1 General Information - Critical Acres 9,774

Land Use	Acres	% Critical Acres
Beef	8,774	90
Citrus	1,000	10

2

Farms	Average Acres	Approx. Animal Units
Beef - 1	1,462	3,000
Citrus - 1	1,000	

3

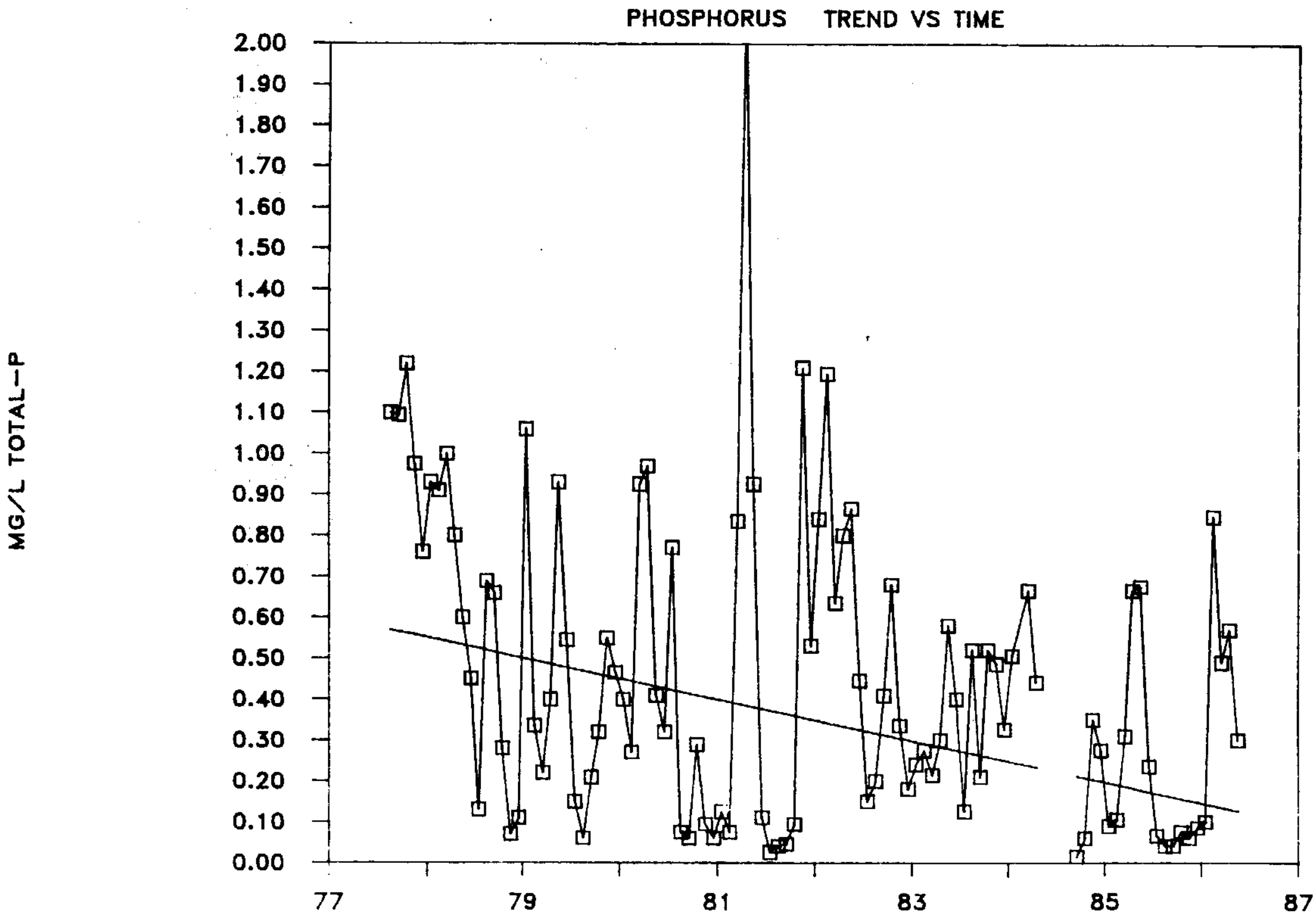
Water Quality Sampling Sites	Site #		Sampling Frequency
Open Channel Grab	07	W Upstream	Biweekly
	08	E Upstream	Biweekly
	09	Downstream	Biweekly

Time series trends of wet season total phosphorus and ortho phosphorus, total nitrogen, and inorganic nitrogen for stations 07, 08, and 09 are presented in Appendix I. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 for stations 07, 08, and 09 are reported in Appendix I.

Discussion

There appears to be little change in the overall water quality in the Williamson sub-watershed. Results of the Kendall Tau test indicate that no significant trend exists for total phosphorus concentrations at station 09, the most downstream site. However, a significant decreasing trend has occurred at the east lateral site 08(Figure 18) . Wet season time series illustrations at stations 08 and 09 indicate some improvement in nitrogen and phosphorus concentration has occurred since 1983. Nitrogen concentrations in particular have exhibited less variability throughout the wet season from 1978 to present. In contrast, station 07, which represents input from the west lateral of this sub-watershed, has exhibited little change in nitrogen and phosphorus concentrations since 1978. Total phosphorus and total nitrogen concentrations at this site are the lowest recorded over the entire Taylor Creek/ Nubbin Sough watershed (< 0.2 mg/L TP and <3.0 mg/L TN respectively).

FIGURE 18. WILLIAMSON DITCH STATION 08



The majority of BMP implementation throughout the Williamson sub-watershed has consisted of fencing cows out of the major drainage. One-hundred percent of the prescribed BMPs have been implemented in the Williamson sub-watershed. The practice of fencing cows out of the stream alone has eliminated the potential of approximately 3,000 cows having access to this drainage. There has also been an interesting change in management philosophy dealing with seasonal fertilizer applications coupled with the use of legumes for supplemental nitrogen fertilization and cattle forage. These practices have been incorporated into the scheme of the largest cattle operation in the Williamson sub-watershed, and one of the largest in the Taylor Creek/ Nubbin Slough watershed, over the last eight years. The most significant management changes have taken place beginning in 1982 and have been progressively implemented over the past five years.

These management changes have been:

1. To shift the normal fertilizer application of 250 to 300 pounds of 20/10/10 per acre from the summer to a late winter/ early spring application.
2. Eliminate all nitrogen fertilization in the summer, relying on legumes to provide nitrogen to forage grasses. (Minimal phosphorus fertilization in the summer consists of a 0/10/30 application).
3. Progressively shift grazing pastures from pangola to a legume-pangola mix providing a natural source of nitrogen to grasses using legumes. This virtually eliminates the need for extensive nitrogen fertilizing during the summer months.

This change in management strategy explains the declining nitrogen concentrations exhibited at station 08 and in turn, downstream at station 09. The seasonal shift in the application of phosphorus fertilizers seems to have helped improve wet season phosphorus concentrations, eliminating slugs of phosphorus during extreme wet periods where high water table/ runoff conditions exist.

Mosquito Creek

General Information - Critical Acres 4,101

1	Land Use	Acres	% Critical Acres
	Dairy	3,663	89
	Beef	438	11
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 4	916	4,000
	Beef - 2	219	150
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	15 Upstream	Biweekly
		13 Downstream	Biweekly

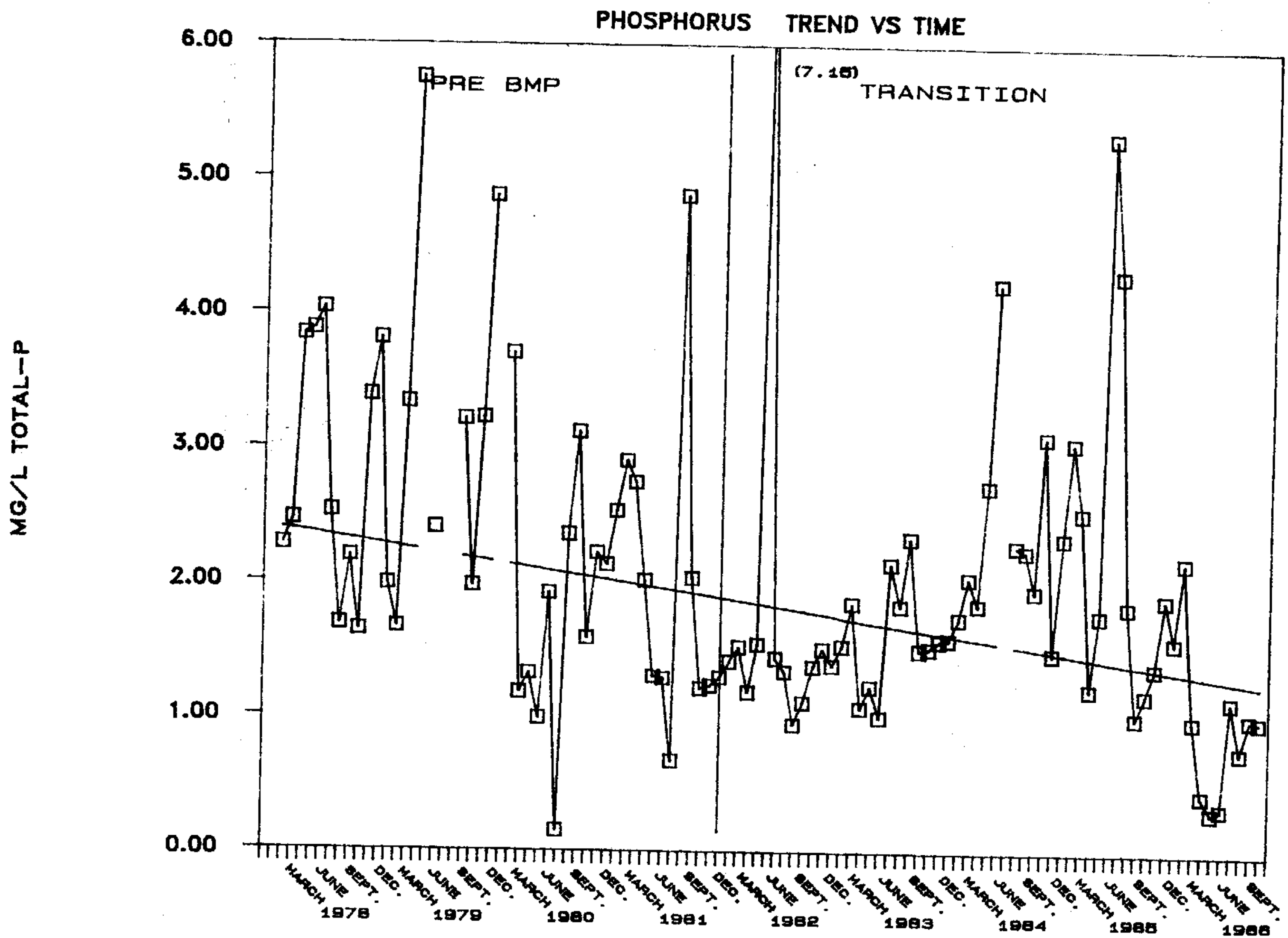
Time series trends of wet season total and ortho phosphorus, total and inorganic nitrogen concentrations for stations 13 and 15 are presented in Appendix I. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 are also presented in Appendix I.

Discussion

BMP implementation along Mosquito Creek has resulted in a significant improvement in downstream nitrogen and phosphorus concentrations as depicted in the wet season time series provided in Appendix I. This downward trend was also apparent in the Kendall Tau trend analysis as illustrated in Figure 19. Fifty percent of the prescribed BMPs have been implemented in the Mosquito Creek sub-watershed, the majority of which has occurred on three dairies located upstream of station 15. Much of the improvement can be attributed to the following on-farm improvements on prescribed BMPs that were implemented after a change in management had taken place at these three barns:

1. More efficient use of barn wash water, reducing from 300,000 gallons per day to 150,000 gallons per day.
2. Fencing all 3,000 cows out of all upstream drainage.
3. Improvement of effluent disposal at a 500 head calf operation.

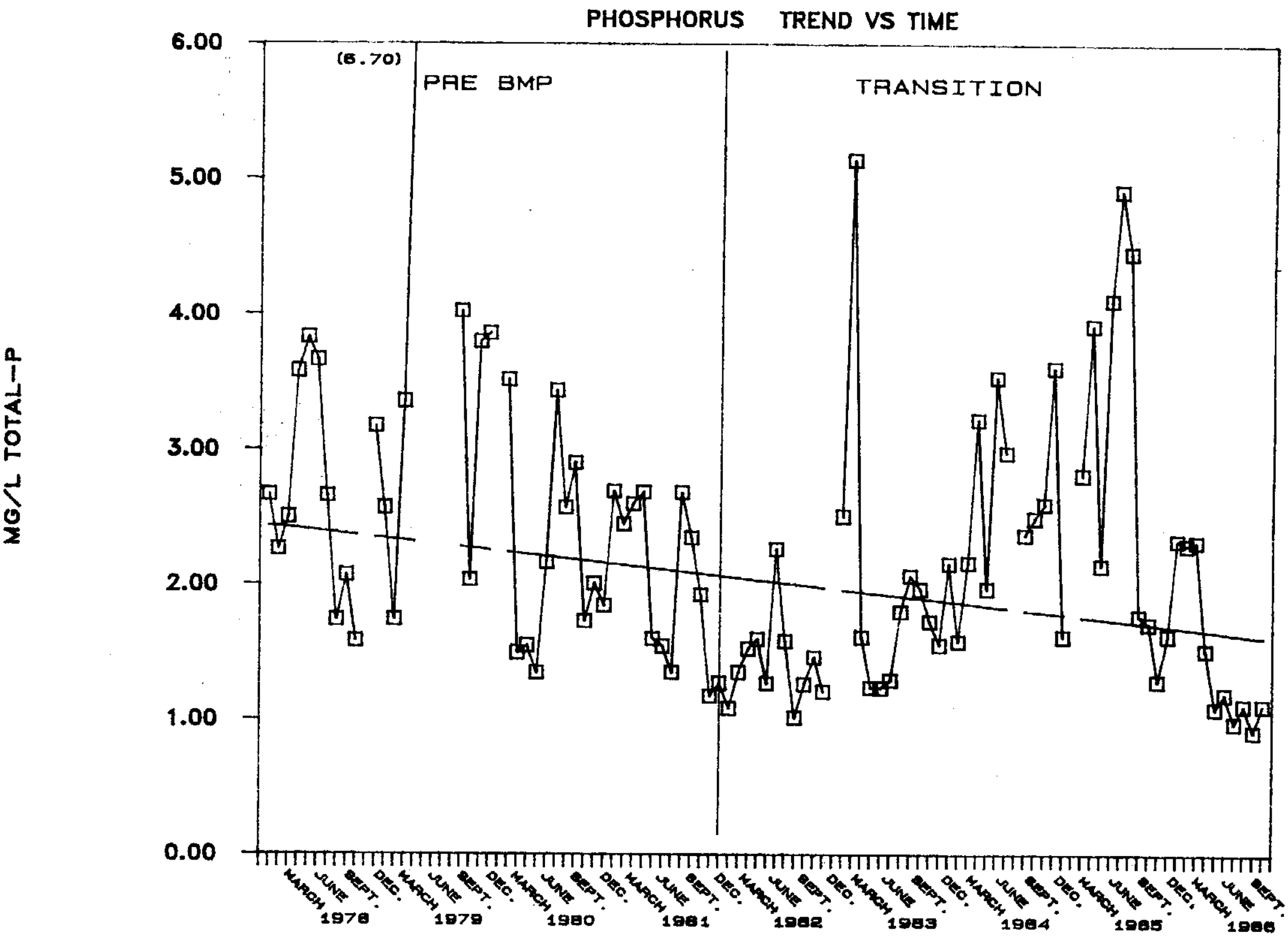
FIGURE 19. MOSQUITO CREEK UPSTREAM STATION 15



4. Improvement of existing seepage disposal fields plugging off all direct drainage to Mosquito Creek.
5. Reshaping and smoothing high intensity pastures and eliminating many on-farm drainage ditches from entering Mosquito Creek.

Additional plans for 1987 are to implement a series of spray irrigation facilities on hay pastures using secondary lagoon effluent from the three barns. This will provide relief for overworked seepage ditches. Little BMP implementation between stations 13 and 15 has occurred over the past year. Much of the improvement in water quality exhibited at station 13 (downstream Mosquito Creek) can be directly attributed to land use changes upstream of station 15, Larson Dairy (Figure 20). However, despite a significant downward trend in phosphorus concentrations at station 13, total and ortho phosphorus concentrations were approximately 10 percent higher in 1986 than those exhibited at station 15 (upstream). This can be attributed to the lack of BMP implementation on the high intensity pastures and lagoons at the White Dairy located directly upstream of station 13 and two miles downstream of station 15. Additional BMP implementation at this dairy and completion of the water quality plans at the three upstream dairies upstream of station 15 should provide additional water quality improvements in this watershed.

FIGURE 20. MOSQUITO CREEK DOWNSTREAM STATION 13



Nubbin Slough

General Information - Critical Acres 7,091

1	Land Use	Acres	% Critical Acres
	Dairy	4,244	60
	Beef	2,058	40
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 6	706	5,000
	Beef - 8	357	950
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	17 Upstream	Biweekly
		14 Downstream	Biweekly

Time series trends of wet season total and ortho phosphorus, total and inorganic nitrogen concentrations are presented in Appendix I. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 for stations 17 and 14 are reported in Appendix I. Mean annual total phosphorus concentrations at station 17 have typically ranged from 0.5 to 0.7 mg/L, while mean annual concentrations at the downstream station have been as high as 3.63 mg/L (reported in 1986).

Discussion

There may be a slight increase in nitrogen and phosphorus constituents in Nubbin Slough. The Kendall Tau test suggests that no significant trends in total phosphorus exist at this time. However, wet season time series trends suggest a slight increase in nitrogen and phosphorus constituents despite the 80 percent BMP implementation. Observed increases in concentrations at station 14 are a result of the downstream site being directly influenced by dairy effluent discharge occurring 700 yards upstream. Midsummer increases in nitrogen and phosphorus concentrations observed during 1986 can also be attributed to a breach in an upstream sediment basin in July. This basin was used to collect high intensity pasture runoff from an upstream dairy. Eighty percent of the prescribed BMPs have been implemented in the Nubbin Slough sub-watershed. Five of the six dairies located in the critical area of Nubbin Slough are downstream of station 17 and upstream of station 14 (Figure 1). The remaining dairy is located approximately three miles upstream of station 17. Runoff from the back pastures of this operation drain into the project area while the dairy and associated high intensity areas drain away from the project area. Until the water quality plan is completely implemented on Red Top Dairy (September 1987), effluent from this operation will continue to mask any water quality improvements resulting from BMP implementation at upstream dairy operations.

Henry Creek

General Information - Critical Acres 4,255

1	Land Use	Acres	% Critical Acres
	Dairy	2,445	57
	Beef	1,810	43
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 1	2,445	1,500
	Beef - 2	905	250
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	39 Downstream	Biweekly

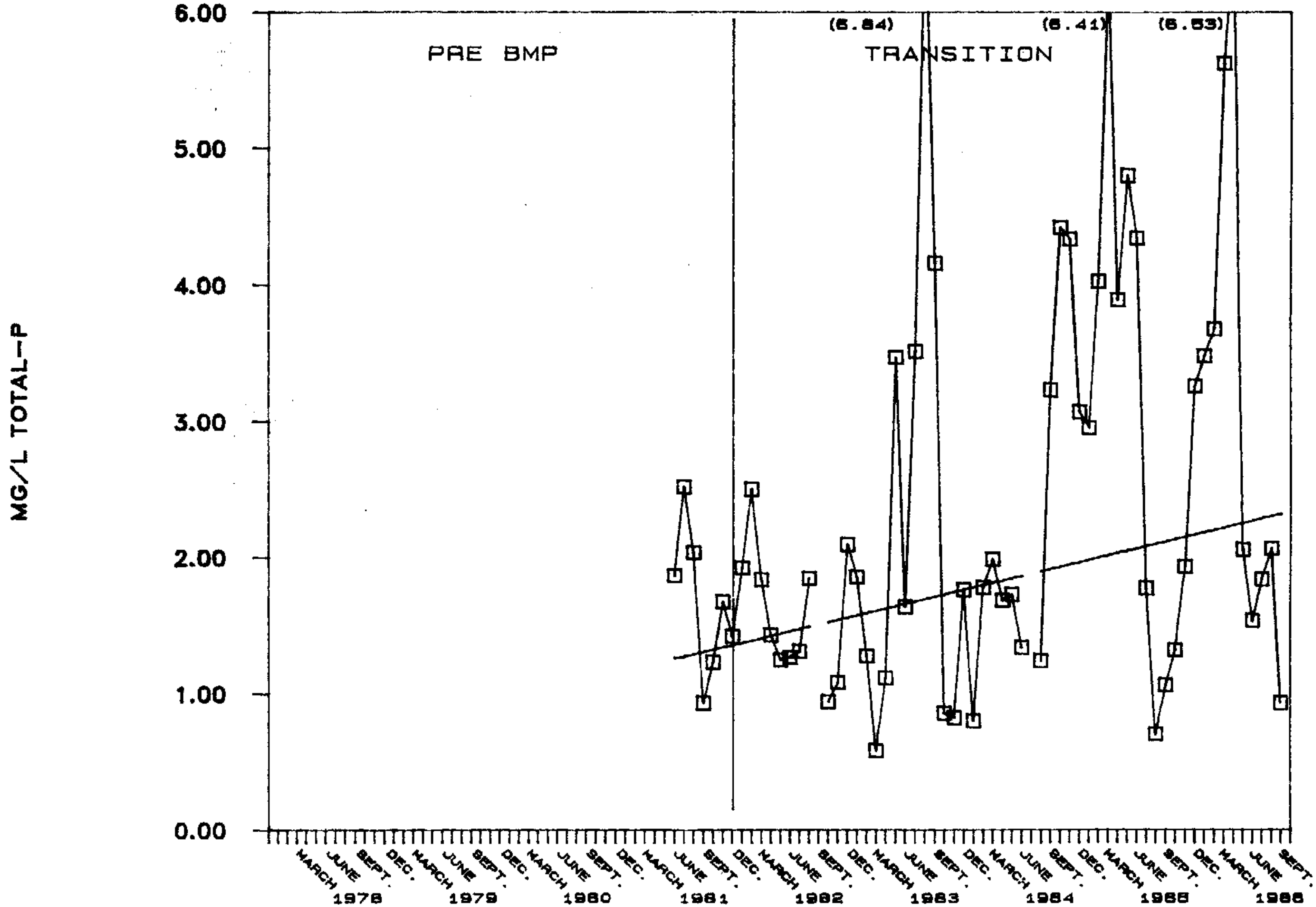
Time series trends of wet season total and ortho phosphorus, total and inorganic nitrogen concentrations are presented in Appendix I. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 for station 39 are reported in Appendix I.

Discussion

Water quality constituents concentrations appear to be increasing in Henry Creek. Ninety-eight percent of the prescribed BMPs have been implemented throughout the Henry Creek sub-watershed. The Kendall Tau test for significance indicated increasing total phosphorus concentrations since 1981 (Figure 21). This trend can be identified in the wet season time series depicted in Appendix I. Secondary lagoon effluent and high intensity runoff from a calf operation have been

FIGURE 21. HENRY CREEK STATION 39

PHOSPHORUS TREND VS TIME



discharged into Henry Creek from Enrico Dairy, upstream, for several years. Because of excessive runoff from these sources they were re-addressed in the SCS water quality work plan and corrected during the latter half of 1986. An interesting note: wet season total and inorganic nitrogen concentrations seemed to decrease during 1986. Recent improvements in the secondary lagoon and calf operation runoff should improve instream phosphorus concentrations in Henry Creek during the 1987 wet season.

Lettuce Creek

General Information - Critical Acres 4,756

1	Land Use	Acres	% Critical Acres
	Dairy	1,143	24
	Beef	3,613	76
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 2	572	1,700
	Beef - 3	1,204	1,000
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	40 Downstream	Biweekly

Time series trends depicting wet season total and ortho phosphorus, total and inorganic nitrogen concentrations are presented in Appendix I. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 for station 40 are reported in Appendix I.

Discussion

Water quality constituent concentrations have exhibited little change in Lettuce Creek. Ten percent of the prescribed BMPs have been implemented in the Lettuce Creek sub-watershed. The majority of this BMP implementation has taken place on one of the dairy operations in the sub-watershed. Results from the Kendall Tau trend analysis for station 40 indicated no significant trend in total phosphorus concentrations since 1981.

BMP implementation in the Lettuce Creek sub-watershed has centered around a spray irrigation system using effluent from a large secondary lagoon for irrigation water. Wet season time series analysis also indicated no significant water quality improvement resulting from the present level of BMP implementation.

S-191 Summary

General Information - Critical Acres 63,109

1	Land Use	Acres	% Critical Acres
	Dairy	32,812	52
	Beef	28,363	45
	Citrus	1,910	3
	Hog	24	>.05
2	Farms	Average Acres	Approx. Animal Units
	Dairy - 29	1,131	31,400
	Beef - 42	675	8,930
	Citrus - 2	955	N/A
	Hog - 2	12	175
3	Water Quality Sampling Sites	Site #	Sampling Frequency
	Open Channel Grab	S-191 Downstream	Biweekly

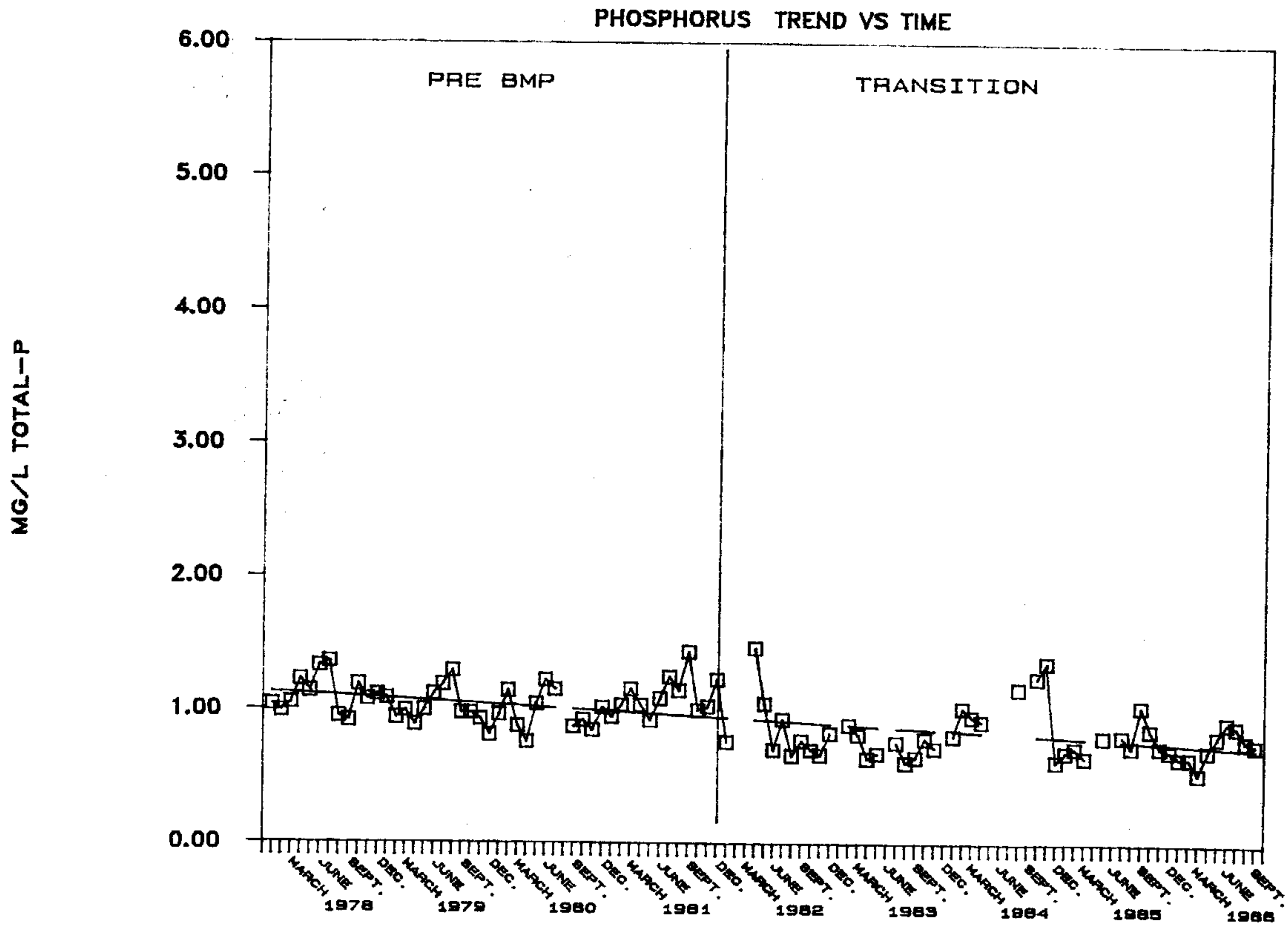
Time series trends depicting wet season total and ortho phosphorus, total and inorganic nitrogen concentrations are presented in Appendix I. Mean, minimum, and maximum values for selected parameters during 1985 and 1986 for station S-191 are reported in Appendix I.

Discussion

Seventy-eight percent of the prescribed BMPs have been implemented throughout the entire Taylor Creek/ Nubbin Slough watershed. Results of the Kendall Tau test at S-191 indicate a slight decreasing trend in total phosphorus concentrations since 1978 (Figure 22). This trend is also apparent in examination of wet season time series data for nitrogen and phosphorus (Appendix I).

In review, the sub-watersheds displaying significant trends in total phosphorus concentrations were: N.W. Taylor Creek, Otter Creek, Mosquito Creek, Henry Creek, Taylor Creek Main, and the outflow of the Taylor Creek/ Nubbin Slough

FIGURE 22. S191 AT LAKE OKEECHOBEE



basin, S-191. N.W. Taylor Creek and Henry Creek exhibited a significant increasing trend in total phosphorus concentrations. The remaining sub-watersheds exhibited an improvement or decrease in total phosphorus concentrations. Decreasing trends in total phosphorus concentrarions observed at Taylor Creek Main (station 11) and the headwaters (station 18) seem to reflect similar decreases exhibited in Otter Creek after the F and R Dairy shutdown. The elimination of point discharges seems to mask potential effects of fencing, a major BMP along the main branch of Taylor Creek and sub-watersheds throughout the Taylor Creek/ Nubbin Slough Basin. External factors that seem to be affecting our ability to determine the water quality impacts of fencing cows out of the major water courses are:

1. The increase in animal densities in the N.W. Taylor Creek sub-watershed has had a negative affect on water quality. Increased cow densities seem to create high intensity areas which, in turn, generate significantly higher amounts of nutrients during runoff and thus negate the effect of fencing cow out of the major water courses.
2. Changes in fertilizer practices and timing of applications override the fencing effect in a positive manner by decreasing concentrations.
3. Point sources of discharge from high intensity grazing pastures mask the effects of fencing on a sub-watershed scale.

The cumulative effect of changes in land use practices on concentrations at S-191 has been positive. Emphasis on efficient waste water utilization (Otter Creek, Mosquito Creek), diversion of direct runoff from high intensity pastures (Mosquito Creek) timing of pasture fertilization (Williamson Ditch) and fencing throughout the watershed seem to have positively influenced total phosphorus concentrations at S-191.

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